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RESEARCH INSTITUTE, NEW DELHI**

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PROCEEDINGS
of the **SOCIETY for**
HORTICULTURAL
=====SCIENCE=====

1914

ELEVENTH ANNUAL MEETING



PROCEEDINGS

OF THE...

Society for
Horticultural Science
1914.



ELEVENTH ANNUAL MEETING,
PHILADELPHIA, PA.



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PROCEEDINGS OF THE SOCIETY FOR HORTICULTURAL SCIENCE.

1914

PRESIDENT CORBETT: It is my pleasure to call to order the eleventh annual meeting of the Society for Horticultural Science. The program which is offered is one of the fullest that has ever been presented and the general character of the topics indicates that the original concept of the Society has been kept well in mind by those on the program committee.

The extent of the program and the number of those assembled to participate in the proceedings demonstrate the need which existed for such a society and the wisdom and good judgment of its founders..

NEW VEGETABLE INTRODUCTIONS.

By D. N. SHOEMAKER, *U. S. Dept. of Agr., Washington, D. C.*

(Since the United States Department of Agriculture will soon issue bulletins on the different vegetables mentioned by Mr. Shoemaker, his address is not printed in this report.)

CLASSIFICATION OF SWEET POTATOES.

By H. M. CONOLLY, *U. S. Dept. of Agr., Washington, D. C.*

(The classification discussed by Mr. Conolly will appear in the near future in a bulletin published by the United States Department of Agriculture.)

PRELIMINARY REPORT ON CELERY STORAGE INVESTIGATIONS.

By H. C. THOMPSON, *U. S. Dept. of Agr., Washington, D. C.*

There are three distinct methods of storing celery, trenching or covering in the field, storing in a common storage house of the cellar or semi-cellar type, and storing in cold storage warehouses. The first two methods are rather old, but the last one is new and the principles involved are entirely different from those involved in either of the first two methods.

Storing celery in cold storage warehouses presents a large number of problems of which none have been fully solved. With a view of studying these problems and, if possible, solving them, the United

States Department of Agriculture started some experimental work on celery storage in 1912. Before taking up the experimental features of the work the speaker made a general study of the problems in the field, in the storage house and on the market, in order to get a definite idea as to what are the most important problems. One of the first things observed was that celery nearly always decays in the center of the crate before it does near the outside, and also that in many cases the whole center decays so badly that it looks as if it had been scooped out. It was also observed that some lots of celery went down in storage much quicker than other lots stored under the same or very similar conditions, and that the celery in the top tier of crates nearly always decayed before that in the lower tiers. The problems are to find the causes of these conditions and then to find the remedies. This called for work in the field to see that the experimental lots of celery were grown and handled under the same conditions, investigations in the storage house to find out if the conditions are the same in all parts of the house, and observations of the celery in transit to see if the temperature is about the same in all parts of the car.

The decay of celery in the center of the large crate appeared to be due to heating caused by lack of ventilation. To test this point several types of crates were made up and were used in storage to compare with the standard crate. One of these was the standard crate with a ventilated partition in the center. The partition divides the crate into two sections and is made by nailing three or four slats on each side of one-inch posts. The posts and slats are the same size as those used for the heads. This type of ventilator allows air to circulate through the crate from the top, bottom and sides. In addition to this crate several smaller ones have been used. The small crates were of four sizes: 10 inches, 12 inches, 14 inches and 16 inches wide, and the same length and depth as the standard crate.

To test these different types of crates a good field of celery practically free from disease was selected from which to secure material for storage. All of the crates were packed and handled as nearly alike as possible. At intervals during the storage period the celery was examined and some was taken out and graded at two or three different times. In 1912, celery was secured from Arkport, N. Y., and stored at Elmira. The celery was harvested October 25 and put in the storage house during the forenoon of October 26. This celery was examined at the end of one, two and three months. When the first examination was made the celery in all of the crates was in nearly perfect condition. At the end of the second month very little difference was noticeable except in the color and slight decay of the foliage in the center of the standard crate. At the end of the third period (Jan. 20 and 21, 1913.) the celery was taken out of storage and prepared for market. It was graded into two grades, No. 1 and No. 2. In five standard crates there was an average of 81 stalks of No. 1 and 15 stalks of No. 2, or 86 per cent No. 1 and 14 per cent No. 2. In 5 partitioned crates and 5 half-crates there

was 1.2 per cent of No. 2 celery. The difference in the market value was even greater than the figures would indicate. The celery in the standard crate had less foliage than the celery in the other crates so did not show up as well on the market. The dealer who prepared it for market estimated that the celery in the partition and half crates was worth at least one-fourth more than that in the standard crate, because of the difference in the amount and color of the foliage.

In 1913, three lots of celery were put in storage, one each from Arkport, South Lima and Rochester. The first two lots were stored at Elmira and the last at Rochester. All of it was examined after being in storage about a month and a half and again a month later. At the time of the first examination it was in good condition and there was practically no difference in the various types of crates. Some of that from Arkport and South Lima was taken out and graded for market on January 22 and 23. There was not a great difference in the appearance of that in the different crates at this time, but when it was taken out and graded there was quite a noticeable difference in the color and amount of foliage and of decay on the foliage. While the size of the stalks largely determines the grade when only two grades are made, this is not the only factor which affects the price. The amount and color of the foliage have considerable influence on market value. While the stalks in the standard crates showed very little decay the foliage was so badly decayed that much of it had to be removed and that not removed was so yellow that it detracted from the appearance of the lot. That in the small and in the partition crates had good foliage and brought 15 to 20 per cent higher price than that in the standard crates.

While the difference in the keeping qualities of celery in the different types of crates was quite marked in January after it had been in storage a little over two and a half months, the greatest difference was shown when the last lots were taken out on February 13, and carefully sorted into 4 grades, No. 1, No. 2, No. 3 or "hearts," and No. 4 (total decay). The results of this grading are shown in the following table:

Type of crate	1st grade		2nd grade		3rd grade		4th grade	
	No.	Per cent	No.	Per cent	No.	Per cent	No.	Per cent
16-inch.....	134	78	31	18	7	4	0	0
Partition....	124	65	54	28	10	5	4	2
Standard....	92	37	96	39	46	19	12	5

It will be noticed that the 16-inch crate gave better results than the partition crate, but this is probably due to the fact that there was a little drip from the pipes on the celery in the upper partition crate. Both the 16-inch crate and the partition crate were much better than the standard crate. It should be borne in mind that this

celery was in storage about a month longer than the ordinary storage period. Other celery in the same room had rotted quite badly a month before this last experimental lot was taken out.

When keeping qualities alone are considered there is practically no difference in the different types of crates for the first month, provided the celery is properly handled before it reaches the storage and that the temperature is kept at 31 or 32 degrees F. During the second month not much difference is seen where the conditions in storage have been the best, but during the third month there is considerable difference, especially in the amount and character of foliage, that in the standard crate showing to a decided disadvantage. The greatest advantage in using small or ventilated crates is in lengthening the storage period. Even under the best of conditions two and one-half or three months are about the limit for celery packed in standard crates, while that in the small or ventilated crates can be kept at least 4 months.

There are many other points to be considered in connection with the type of crates such as cost, durability and ease of handling. The standard crate is the cheapest in proportion to the amount of celery it will carry, but it is easily broken and is very unwieldy to handle. The ventilated partition crate is as unwieldy to handle and costs 20 to 25 per cent more than the standard crate, but it is decidedly more durable and keeps the celery in much better condition. Many of the slats on the standard crates are broken in handling and piling and this allows the upper crates to crush the celery in those below. This crushing and bruising not only injures their appearance but causes breaks in the stems through which disease germs may enter. The partition crate has three points of support instead of two so that when stacked the weight of the upper crates is distributed over the ones below. The units of the partition crate are too small to allow the corner of one crate to project down into the one below. The speaker believes that a crate smaller than the standard is to be preferred because of ease in handling. The celery will keep better in a small crate than in a large one without a ventilator, and the smaller one will not be so badly broken in handling. The increased cost of small crates would be made up many times by the higher price received for the celery. In many cases the large crates are so badly broken before they reach their destination that they have to be patched up or new ones made before the celery can be marketed. The cost of the extra work is considerable, but this is not so important as the injury done to the celery by crushing when the crates collapse by extra handling. The speaker has seen celery come on the market in such a condition that the value was not more than one-half what it should have been simply because the crates were broken and the celery badly bruised and crushed.

TEMPERATURE RECORDS IN CARS DURING TRANSIT.

In order to find the amount of variation in temperature in different parts of the car while in transit, readings were taken in five cars

of celery. These readings were made by means of electrical thermometers with cable attachments. By using the cable attachments it is possible to take temperature readings in a number of places in the car without opening the doors or vents. In the work this season temperature readings were taken in twelve places in the car, namely, in the celery in the bottom crate at front end, rear end, and centre of car, in the celery in the top crate at front end, rear end, and centre of car, and in the air alongside each of these crates. These readings were taken in five cars of celery, two from South Lima, N. Y., to Jersey City, and three from South Lima to Hornell, N. Y. The length of time the celery was in transit from South Lima to Jersey City was 36 hours and 66 hours, including the time the cars were in the yards before they were unloaded. The cars shipped from South Lima to Hornell were in transit from 18 to 24 hours.

The records secured this season show that there is a great difference in the temperature of the celery and of the air at the different heights and in different parts of the car. The highest celery temperature was in the top crate in the center of the car, and the lowest celery temperature was in the bottom crate in the front end of the car. The highest air temperature was at the top crate in the center of the car and the lowest air temperature was at the bottom crate in the front end of the car. There was some difference between the air and celery temperatures at the same locations in the car. The following table gives the highest, lowest and average celery and air temperature in an iced car shipped from South Lima, N. Y., to Jersey City:

	Beginning of Trip.	End of Trip.
Highest in celery.....	57½ degrees F.	62½ degrees F.
Lowest in celery.....	37½	32½
Average in celery.....	51½	49½
Average in celery, top tier...	54½	59½
Average in air, top tier.....	56½	50
Average in celery, bottom tier	49	41
Average in air, bottom tier...	45	36

It will be noticed that the difference between the highest and lowest celery temperature at the beginning of the trip was 20 degrees and at the end of the trip 30 degrees. In other words the temperature of the celery in the top crate in the center of the car went up while that in the bottom crate in the front end of the car went down. This accounts for the greater difference in the highest and lowest celery temperature at the beginning and end of the trip. The average celery temperature in the top tier was 9½ degrees higher than the average air temperature at the same place, while in the bottom tier the average celery temperature was only 5 degrees higher than the average air temperature.

In one iced car shipped from South Lima to Hornell the temperature records are as follows:

	Beginning of Trip.	End of Trip.
Average in celery, top tier....	63 degrees F.	64 degrees F.
Average in air, top tier.....	60½	57½
Average in celery, bottom tier	62	52½
Average in air, bottom tier...	50	45
Average in air, center of car.	63	58½
Average in air, A end of car..	48	47
Average in air, B end of car..	47½	43
Outside air.....	62	71

The temperature of the outside air dropped from 62 degrees at 6:30 P. M., October 21, to 47 at 4:00 A. M., October 22, then went up to 71 degrees at 11:00 A. M. It will be noticed, however, that the outside air had no appreciable influence on the inside air or celery temperatures.

In a car shipped without ice from South Lima to Hornell the temperature records are as follows:

	Beginning of Trip.	End of Trip.
Average in celery, top tier...	49 degrees F.	50 degrees F.
Average in air, top tier.....	47½	46
Average in celery, bottom tier	46½	46½
Average in air, bottom tier....	45½	45½
Outside air.....	52	49

The temperature of the outside air dropped from 52½ degrees at midnight, October 31, to 38 at 6:45 A. M., November 1, then went up to 49 at 8:45 A. M. It will be noticed that there was not so much difference in the temperature in different parts of this car as in the iced cars, but the fact that the celery was cool when loaded and that the outside air was lower in temperature than it was when the iced cars were shipped probably accounts for this difference.

All of the car temperature records show that there is quite a difference in temperature at different heights in the car, both in the ends and in the center. There is also quite a difference in temperature between the ends and center of the car, and between the air and celery temperature at the same location. These temperature records are so similar to those secured with fruit in transit that the speaker believes the same principles are involved and that the same remedies are applicable. Pre-cooling has been found of great value in fruit transportation and there is no reason to believe that it will not be just as satisfactory for vegetable transportation. When fruit is pre-cooled, there is not so much difference in the temperatures in different parts of the car, and the temperature does not go so high as where it is not pre-cooled. By pre-cooling, the celery would be cooler when started from shipping point and would reach the storage house at a much lower temperature than it does under present conditions. Keeping the temperature low in transit would shorten the time required to bring the celery to refrigeration temperatures in storage and lengthen the storage period.

TEMPERATURE RECORDS IN STORAGE.

In the storage house, temperature records have been secured to show the difference in air temperature at different heights, difference between air and celery temperature at the same height and difference in celery temperature in different sized crates. These readings have been secured by means of air thermographs and air-soil thermographs. Last year the records covered a period of over three and one-half months (October 27, 1913, to February 13, 1914) and included temperature of the air at the top of the 1st, 2nd and 4th tiers of crates, and the celery temperature in the 2nd and 4th tiers. This year the following records are being secured: Temperature of celery in center of standard crate, partition crate, and 16-inch crate; temperature of air one foot from floor, at top of third tier of crates, and at top of fifth tier of crates.

The temperature records for last season (1913-14) are given in the following table:

Period No.	Days	Air at top of 4th tier degrees	Celery in 4th tier degrees	Air at top 1st tier degrees	Date
1	3	37 to 34	55 to 36	32 to 30	Oct. 27 to Oct. 30
2	7		36 to 34	30 to 31	Nov. 17 to Nov. 24
3	7		34 to 34	32 to 31	Nov. 24 to Nov. 31
4	7	30 to 30	34 to 34	30 to 30	Dec. 16 to Dec. 23
5	7	30 to 28	34 to 35	30 to 32	Dec. 23 to Jan. 6.
6	7	28 to 30	34 to 35	30 to 32	Dec. 30 to Jan. 6
7	7	32 to 29	36 to 35	30 to 30	Jan. 6 to Jan. 13
		(Moved to 2nd tier.)	(Moved to 2nd tier.)		
8	7	29 to 30	35 to 34	30 to 30	Jan. 13 to Jan. 20
9	7	28 to 30	33 to 35	30 to 30	Jan. 20 to Jan. 27
10	7	28 to 30	35 to 36	32 to 32	Jan. 27 to Feb. 3
11	7	28 to 36	35 to 36	30 to 31	Feb. 3 to Feb. 10
12	3	28 to 28	34 to 35	34 to 34	Feb. 10 to Feb. 13

The above table shows a lower temperature at the top of the fourth tier than at the top of the first tier, but this is due to the fact that the thermograph which recorded the temperature at the height of the first tier was near the door while the thermograph on the fourth tier was near one corner of the room. There was no place to put a thermograph at the height of the first tier at the time this celery was put in except near the door because the room was full of celery. The temperature of the air at the top of the fourth crate is comparable with the celery temperature in the fourth crate as the two thermographs were side by side. The table given above shows that the records were not kept from November 31 to December 16. This was due to the fact that the foreman of the storage house was so busy he forgot the thermographs. The records are, however, com-

plete enough to show the difference in temperature between the celery and the air.

The temperature records for this year (1914-15) are given in the table below:

Period		Celery in stand- ard crate degrees	Celery in parti- tion crate degrees	Air one foot from floor degrees	Air, top of 3rd tier degrees	Top of 5th tier degrees
No.	Days					
1	3	67 to 37	65 to 37		27 to 33	
2	3	36 to 36	35 to 34		32 to 34	
3	7	36 to 35	33 to 34		32 to 32	37 to 35
4	7	35 to 35	35 to 34	32 to 31	33 to 33	36 to 34
5	7	36 to 35	35 to 34	32 to 31	32 to 31	35 to 33
6	7	36 to 37	34 to 34	31 to 30	31 to 30	34 to 34

The records given above are not as complete as desired because in some instances the pens failed to make a mark and in others the record sheets were so blurred that the line could not be made out with certainty. The thermograph used in the 16-inch crate did not record correctly so the records are not used in this paper. It should be borne in mind that this work had been carried on a long distance from headquarters and that it has been necessary to depend on inexperienced men to change the record sheets and keep the thermographs running. The speaker visits the storage houses three or four times during the storage period to examine the celery and to see that the thermographs are properly regulated. It would be much better if someone interested in the work could visit the house once a week to change the records and note the condition of the celery.

The records taken in the storage house show that the celery runs higher in temperature than the air at the same height. The greatest difference between the celery and air temperature is at the beginning of storage when celery is being brought in from the outside. Toward the end of the storage period when there is considerable decay there is also quite a difference between the temperature of the air and celery. After the celery has been cooled there is a period of several weeks when the temperature does not show much variation.

Last year the temperature of the celery was 4 to 7 degrees higher than the air at the same height, the smallest difference being after the celery was thoroughly cooled and before decay set in. This year, for a period of two months, the temperature of celery in the center of a standard crate in the third tier has been 2 to 6 degrees higher than the temperature of the air at the same location. The celery in the partition crate has been 1 to 2 degrees lower than that in the standard crate. The temperature of the air at the top of the fifth

tier has been 2 to 4 degrees higher than at 1 foot from the floor, and 2 to 3 degrees higher than at the top of the third tier. No doubt there would have been a greater difference in temperature between the top and bottom if no records were being kept for as soon as the temperature at the top of the room gets much higher than at lower levels the room is ventilated and electric fans started to change the air. In many storage houses very little attention is paid to ventilation and circulation of air and in these there is a greater difference in temperature between the top and bottom of the room than where ventilation is given. Even if close attention is paid to ventilation and circulation, the celery in the top crates decays sooner than that in the lower crates, but the difference is not so great as in poorly ventilated houses or where the air is not moved.

The temperature records secured during the past two years and observations in a large number of storage houses the past three years have led the speaker to conclude that celery is never inactive while in storage. For a period of several weeks, the length of time depending upon the stage of ripeness of the celery when stored and upon the conditions in the storage house, normal maturing processes go on in storage even at a temperature of 31 or 32 degrees until the celery is ripe. When the ripening processes cease decomposition sets in and never stops until the celery is completely decomposed. Of course, the rate of ripening and of decomposition depends upon the temperature maintained in the storage house. Where the temperature is maintained between 30 and 32 degrees the rate of ripening and decomposition is slow. The greater the variation or fluctuation in temperature, the shorter the storage period. When the temperature goes above 32 there is a sweating of the walls, pipes and celery and this moisture aids decay. In both ripening and decomposition, heat is given off and this accounts for the fact that the temperature of the celery is higher than that of the air at the same location.

FERTILIZER EXPERIMENTS WITH KALE.

BY T. C. JOHNSON,

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The truck farmers in Eastern Virginia follow a system of crop rotation which requires the use of the land for vegetables practically twelve months in the year. The large acreage devoted to this work renders it difficult to obtain sufficient stable manure to maintain the soil fertility, hence they have been forced to resort to the use of large quantities of commercial fertilizers. Frequently 1500 to 2000 pounds per acre of these materials analyzing 6 per cent nitrogen, 5 per cent phosphoric acid and 6 per cent potash will be applied to the land for a crop of potatoes which is planted in February and harvested in June. The potatoes are followed immediately by corn or an annual grass, which in turn is followed by spinach

in September or October. The spinach received from 1000 to 2000 pounds of fertilizer analyzing 8 per cent nitrogen, $3\frac{1}{2}$ per cent phosphoric acid and 2 per cent potash. Early cabbage plants are set between the spinach in January. Sufficient plant food remains from the spinach to start a rapid early growth, but from 500 to 800 pounds more fertilizer are added late in March to stimulate early heading. The cabbage is usually followed with cow peas which are turned under preparatory to repeating the rotation. It will thus be seen that from 3000 to 4500 pounds of high grade commercial fertilizer are used per acre in the two-year rotation practiced. It is hardly necessary to add that marked injuries to the plants frequently follow this excessive and injudicious use of commercial fertilizer.

In 1908 we inaugurated a series of experiments to determine the best methods of treating these lands to maintain their fertility. A tract of Norfolk sandy loam soil which had not been previously treated with commercial fertilizers was selected for the work. It was divided into a series of plats, one-twentieth of an acre each, extending north and south. The plats were sub-divided into eight sections extending east and west. Sections one to four in all of the plats were cropped with two vegetable or forage crops annually. No humus or vegetable matter was added to these sections except the roots of the plants which were unavoidably left in the ground when the crops were harvested.

In the first five years of the experiments, sections 5 in all the plats produced potatoes in the spring and crimson clover was sown after the potatoes were harvested in July. The clover was turned under the next spring before planting the potatoes. Sections 6 were treated similarly to sections 5, except they were given four applications of 1500 pounds of hydrated lime per acre during the continuation of the experiments. Sections 7 were given an annual application of fifteen tons of stable manure, and four applications of 1500 pounds each of hydrated lime per acre during the experiment. Sections 8 were treated similarly to sections 7, except they did not receive any lime. Sections 7 and 8 were planted to potatoes in the spring and followed by corn in July of each year. Each plat was given an annual application of commercial fertilizer as follows:

Plat B-73.—Nitrogen 4 per cent (nitrate of soda 2 per cent, sulphate of ammonia 2 per cent)

Phosphoric Acid 6 per cent

Muriate of Potash 8 per cent

4000 pounds per acre.

Plat B-74.—Nitrogen 4 per cent, (nitrate of soda 2 per cent, sulphate of ammonia 2 per cent)

Phosphoric Acid 6 per cent

Sulphate of Potash 8 per cent

4000 pounds per acre.

- Plat B-75.—Nitrogen 4 per cent (nitrate of soda 2 per cent, sulphate of ammonia 2 per cent)
 Phosphoric Acid 6 per cent
 Muriate of Potash 8 per cent
 2000 pounds per acre.
- Plat B-76.—Nitrogen 4 per cent (nitrate of soda 2 per cent, sulphate of ammonia 2 per cent)
 Phosphoric Acid 6 per cent
 Sulphate of Potash 8 per cent
 2000 pounds per acre.
- Plat B-78.—Sulphate of Ammonia, 20 per cent nitrogen
 800 pounds per acre.
- Plat B-79.—Nitrate of Soda, 14 per cent nitrogen
 1200 pounds per acre.
- Plat B-83.—Acid (Rock) Phosphate. 16 per cent available phosphoric acid
 2000 pounds per acre, first year
 1000 pounds per acre, subsequent years.
- Plat B-86.—Floats (untreated)
 4000 pounds per acre, first year.
 2000 pounds per acre, subsequent years.
- Plat B-88.—Kainit, 12 per cent actual potash
 1000 pounds per acre.
- Plat B-89.—Sulphate of Potash, 50 per cent actual potash
 500 pounds per acre.
- Plat B-90.—Sulphate of Potash, 27 per cent actual potash (also impurities)
 500 pounds per acre.
- Plat C-75.—Nitrogen 4 per cent (nitrate of soda)
 Phosphoric Acid 10 per cent
 1000 pounds per acre.
- Plat C-77.—Nitrogen 4 per cent (nitrate of soda)
 Muriate of Potash 8 per cent
 1000 pounds per acre.
- Plat C-84.—Phosphoric Acid 10 per cent
 Muriate of Potash 8 per cent
 1000 pounds per acre.

After the spring crops were harvested in 1912 the entire field was plowed and the surface harrowed occasionally to conserve moisture and prevent the growth of weeds. Immediately before planting the kale, August 7, the commercial fertilizers were sown broadcast over the respective plats and worked into the soil with the disc harrow.

The germination over the entire field was very good, but after a few days the plants on Sections 1, 2, 3 and 4 of all of the plats on which no phosphoric acid had been applied, showed a weak growth and a few days later most of them were dead. On August 19 those portions of the plats were reseeded. The plants from the second sowing germinated in a few days as did the first, but were

soon seen to be in a weak condition, and most of them died before the middle of September. On September 20 plants were taken from other portions of the field and transplanted to these portions, thus providing a complete stand over the entire field. The transplanted plants remained alive until harvest, but made little or not any growth as shown by the yield records.

A portion of the crop from each plat and section was harvested December 17 and 18, 1912, and the balance January 29 and 30, 1913. The ground was reworked and set with cabbage plants immediately. This crop was harvested in June. Sections 5 and 6 were sown to cowpeas, and Sections 7 and 8 received their annual application of fifteen tons of stable manure per acre. The entire tract was re-plowed the last of July and commercial fertilizers were applied as in former years and the kale seeds were planted on August 7.

The plants showed similar peculiarities in germination and growth to those in 1912. Again plants were transplanted to the poor portions in order to obtain a complete stand. This crop was harvested December 9 and 10, 1913. The ground was plowed immediately, and cabbage plants from cold frames transplanted to the field the first of February, 1914. The cabbage was harvested in June.

The yield from the crop of kale grown in the fall of 1913 was considerably less than that in 1912, but this may be accounted for by the weather conditions prevailing during the months of September, October and November, 1913. The yield of Plat B-74 was much larger than that of B-73. These two plats received the same quantity of commercial fertilizer, but the potash of B-74 was obtained from sulphate of potash, and that of B-73 from muriate of potash. B-75 and B-76 received only one-half as much of the same kind of fertilizer as did B-73 and B-74, yet the average kale yield for the two years was 11.6 per cent greater, showing clearly that the latter received too much fertilizer for this crop. The kale average yield from plat B-74 and B-76 was 21.4 per cent greater than were the similar yields from plats B-73 and B-75, showing that sulphate of potash gave better results with this crop on this type of soil than did muriate of potash.

Plats B-77, B-91, C-86 and C-90 received no fertilizer whatever, but were used as check plats. The average yield from them was 225.6 pounds.

B-78 and B-79 received equal and excessive amounts of nitrogen in the form of sulphate of ammonia and nitrate of soda respectively, but no phosphoric acid or potash.

The yield from the sulphate of ammonia treatments was 52.4 per cent below, and from the nitrate of soda 42.5 per cent above, that of the check plat. Sections 1, 2, 3 and 4 of the sulphate of ammonia plat gave an average yield of .75 pounds per square rod; section 5 with crimson clover 3.37 pounds; section 6 with clover and lime 16 pounds; section 8 with stable manure 25.75 pounds, and section 7 with stable manure and lime 59.62 pounds. The corresponding yields for the nitrate of soda treatments were 26.41, 21.12, 52.87,

58.5 and 83.37 pounds respectively. By the addition of lime to section 7, the nitrate of soda and manure yield was 42.5 per cent greater, and the sulphate of ammonia yield 131.6 per cent greater than on section 8, which received manure but no lime. The corresponding yields on the crimson clover section were increased by the use of lime 150.6 per cent and 374 per cent respectively. These results would seem to indicate that the injurious effects of excessive applications of these chemicals may be partly counteracted by liberal use of lime.

Plat B-83 received 100 pounds of 16 per cent phosphoric acid and produced an average yield of 430.87 pounds, while B-86 was treated with 200 pounds of 28 per cent floats and produced an average yield of 509 pounds. Sections 1, 2, 3 and 4 of plat B-83 gave an average yield of 46.53 pounds; section 5 with crimson clover 73 pounds; section 6 with crimson clover and lime 83.25 pounds; section 8 with stable manure but no lime 61.37 pounds and section 7 with stable manure and lime 76.75 pounds, while similar sections of plat B-86 produced 51.75 pounds, 83.25 pounds, 79.50 pounds, 65.00 pounds and 74.25 pounds respectively. Lime with stable manure increased the yield of section 7, plat B-83, 22.5 per cent, and of section 7, plat B-86, 13.8 per cent over stable manure alone, and lime with crimson clover increased the yield of section 6, plat B-83, 13.4 per cent over crimson clover alone. But lime with crimson clover on similar sections in B-86 decreased the yield 6.3 per cent below that of crimson clover alone. This decrease is probably explained by the excess of lime contained in the floats.

Plats B-88, 89 and 90 received applications of various forms of potash without either nitrogen or phosphoric acid. They produced 198.5, 199.12 and 211.37 pounds respectively, or 12 per cent, 11.7 per cent and 6.3 per cent less than did the check plats. Sections 1, 2, 3 and 4 of these plats produced an average of only 2.3 pounds of kale per square rod. On sections 5, 6, 7 and 8 the yields were 21.12 pounds, 39.5 pounds, 67.3 pounds and 63.5 pounds respectively. Lime increased the yield of the manure-potash sections 5.4 per cent and that of the crimson clover-potash sections 86.7 per cent.

Plat C-75 was treated with 1000 pounds per acre of a fertilizer combination, 4 per cent nitrogen, from nitrate of soda; 10 per cent phosphoric acid, from 16 per cent acid (rock) phosphate. The average yields for sections 1 to 4 was 73.4 pounds per square rod; section 5, 84.5 pounds; section 8, 94.5 pounds. The total yield of the plat was 637.35 pounds. The lime increased the manure yield in this plat 21.7 per cent, and the crimson clover yield 7.1 per cent. Plat C-77 was treated with 1000 pounds per acre of a fertilizer mixture containing 4 per cent nitrogen, from nitrate of soda, and 8 per cent potash, from muriate of potash. Sections 1 to 4 in this plat which received no humus or other organic matter in this experiment produced no marketable kale. Section 5 with crimson clover produced an average of 2 pounds; section 6 with crimson clover produced an average of 2 pounds; section 6 with crimson clover and lime 17.75 pounds; section 8 with stable manure 42.5 pounds and

section 7 with stable manure and lime 77.37 pounds per square rod. The total yield for plat C-77 was 139.6 pounds, which is 38.1 per cent less than the check plats which received no commercial fertilizers.

Plat C-84 was treated with 1000 pounds per acre of fertilizer analyzing 10 per cent phosphoric acid from acid phosphate, and 8 per cent potash from muriate of potash. Sections 1 to 4 which received no organic matter produced an average of 36.47 pounds of kale. Section 5 on which crimson clover without lime had been grown produced 77.87 pounds. Section 6 with crimson clover and lime 95.62 pounds. Section 8 with manure produced 68.25 pounds, and section 7 with stable manure and lime produced 80.37 pounds. The total yield for the plat was 465.25 pounds. By the addition of the lime the kale yield from crimson clover section was increased 22.8 per cent, and the yield from manured sections 17.7 per cent.

As a result of these experiments we are forced to the following conclusions:

First.—The use of excessive amounts of complete commercial fertilizers is not necessarily followed by corresponding increases in production.

Second.—The results obtained from the use of muriate of potash in complete fertilizers are less satisfactory than are those obtained from the use of sulphate of potash.

Third.—The use of either sulphate of ammonia or nitrate of soda in excessive quantities is not to be recommended. But sulphate of ammonia is much more injurious than is nitrate of soda.

Fourth.—Phosphoric acid may be used profitably without the addition of either nitrogen or potash, but its beneficial effects when so used are more apparent if the land is supplied with liberal quantities of stable manure or other forms of organic matter.

Fifth.—The use of potash without phosphoric acid is not to be recommended.

Sixth.—The use of phosphoric acid and nitrogen gives satisfactory results when used in combination with stable manure or crimson clover.

Seventh.—The use of nitrogen and potash without liberal quantities of phosphoric acid is not to be recommended.

Eighth.—Lime materially increased the yield obtained from both stable manure and crimson clover treated plats with all of the commercial fertilizer combinations tested except when the phosphoric acid was obtained from floats.

It is customary for the farmers to use a fertilizer analyzing 8 per cent nitrogen, from $3\frac{1}{2}$ per cent to 5 per cent phosphoric acid and 2 per cent potash for top dressing spinach in the cool winter months.

In accordance with the results mentioned above, two fertilizers, one containing 8 per cent nitrogen, 7 per cent phosphoric acid and 2 per cent potash, and the other 8 per cent nitrogen, $3\frac{1}{2}$ per cent phosphoric acid and 2 per cent potash, were compounded and used

for top dressing spinach during the winter of 1913-14. Plats treated with the 7 per cent phosphoric acid fertilizer produced 298 barrels, and the one with the $3\frac{1}{2}$ per cent phosphoric acid produced 216 barrels per acre. It will thus be seen that by increasing the phosphoric acid content from $3\frac{1}{2}$ to 7 per cent, 37.9 per cent gain in yield was obtained.

From these data it would seem that fertilizer for use on kale and spinach should contain higher per cent of phosphoric acid and less potash than those in common use.

POTATO BREEDING AND SELECTION.

BY WILLIAM STUART, *U. S. Dept. of Agr., Washington, D. C.*

(Mr. Stuart's address is now being printed as United States Department Agriculture Bulletin No. 195.)

AN INVESTIGATION IN TOMATO BREEDING.

BY F. S. REEVES,

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The matter that I have to report is the work of one season only and while none of the results are definite either negatively or positively, yet they indicate the possibility of results and give encouragement for further work. In the spring of 1914 an experiment was outlined to cross the tomato with *Solanum balbisii* in an effort to get the frost resistant qualities of the latter, without its undesirable qualities, incorporated into the tomato. It was not known whether these two plants would cross or not, their botanical relationship being so wide, yet it was considered worth the effort.

The tomato in Ontario is grown largely for canning factory purposes as well as for supplying the fresh fruit trade. The plants are never set into the field until about the 24th of May although we usually get four or five weeks of beautiful growing spring weather before this, and in the fall in many districts there is danger of losing a portion of the crop by frost before all the fruits are ripened. It was with the object in view of producing a plant that will stand these early and late drops of temperature that this experiment was undertaken.

The *Solanum balbisii* seemed to be an admirable plant with which to work for it will stand 5 or 6 degrees of frost without the slightest injury to the flowers and at least eight degrees without injury to the growing points in the fall. Although no actual data have been obtained with regard to the amount of cold it can stand in the spring when the plants are young, yet from observations it is known that it can endure more cold than young tomato plants can endure.

The *Solanum balbisii* is a native of South America, but the stock used came to us from Ireland where this plant is, I believe, grown

as an ornamental annual. The flowers are racemose: calyx 5 parted; corolla light blue to white, five lobed, 1 to 1½ inches in diameter; fruit red, globose; leaves deeply pinnatifid, lobes oblong, sinuate or even again pinnatifid. The whole plant is much armed with strong and formidable spines and blooms profusely through the season.

The tomato plants used in this experiment were grown by themselves, at least 300 feet from any other tomato plants and equally as far from the *Solanum balbisii*. There were no other *Solanum balbisii* plants grown within 1000 feet of those used in the experiment.

Fifteen hundred tomato flowers were emasculated and pollinated with *Solanum balbisii* pollen and from these 288 or 19.2 per cent fruits developed. These fruits were slow in reaching maturity, and about half of them ripened without attaining normal size. Under the circumstances this would not be expected as there were only a few fruits on each vine, twenty-four being the greatest number on any one vine. These fruits contained undeveloped seeds, but there were a few plump seeds in ten fruits of which two had all of their seeds fully developed. One of these two fruits remained green and never took on the characteristic color of a ripe tomato although it seemed to ripen otherwise; the seeds were plump and normal in appearance but small in size. The developed seeds in the other fruits were found in the same cells with the undeveloped seeds.

Fifteen hundred *Solanum balbisii* flowers were also emasculated and pollinated with tomato pollen. From these about 40 fruits persisted but none attained normal development. In most cases the ovary had swollen to about one-fourth inch in diameter and in only eight were seeds found, these varied from one to forty-three per fruit. These seeds were normal in size, but the fruit attained size only in proportion to the number of seeds contained. The normal fruit is one inch in diameter containing from 100 to 150 seeds.

The same number of emasculations were made on both plants for a parthogenetic test, but no fruits set on the tomato and only a few on the *Solanum balbisii*. Three of the latter contained seeds, one having one seed, one three, and one twelve.

In an experiment on the self-fertility of *Solanum balbisii* it was found that forty per cent of the flowers set when pollinated from the same plant, 100 per cent when pollinated from another plant and none when pollinated from the same flower.

The tomato fruits which develop scale-like seeds appear to be a desirable class of fruit from the domestic point of view, and it may be possible by careful breeding to obtain a tomato that will produce seedless fruit as large as the seeded fruits we now have. In Bulletin No. 22 of the Bureau of Plant Industry, Mr. Hartley states—"While a comparison of the experiments in which the flowers were emasculated and never pollinated with the experiments in which the flowers were emasculated and magnesium sulphate substituted for pollen would seem to suggest that the irritation of the receptive stigmas may stimulate the setting of fruits, yet fruits set so rarely without flowers having received pollen that a very large

number of flowers would have to be tested in order to determine whether the mere irritation of the stigmas by the application of substances other than pollen has any tendency to cause the fruit to set." He further says, "The large size of seedless bananas and pineapples indicates that the production of seedless tomatoes is possible. But since the most convenient way of propagating the tomato at present is by means of seeds it is not a tomato entirely seedless that is wanted, but a large well shaped firm fruit with but few seeds."

STUDY OF THE INHERITANCE OF SIZE AND PRODUCTIVENESS IN PEDIGREED STRAINS OF TOMATOES.

BY C. E. MYERS,

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The plant breeding work with vegetables now being conducted by the Department of Horticulture at the Pennsylvania State College and Experiment Station, is the outgrowth of rather extensive strain tests of cabbage and tomatoes which were begun in 1908 and concluded in 1911. These tests showed conclusively that differences, apparently due to inheritance, are present within varieties and that these differences represent an economic value of greater extent than would be possible to secure by any change in environment, due to improved methods of fertilization or culture.

From the time the subject of plant breeding has attracted attention a common axiom has been "the plant is the unit of selection." It has been expounded from the platform of the scientific lecturer and become a proverb in the classroom. I am of the opinion, however, that unfortunately in many instances it is neither understood nor fully appreciated.

It was for the purpose of securing additional information on this and allied subjects that the experiments with tomatoes were instituted at the Pennsylvania State College. The initial selections were made in 1911 and the first crop was grown the following year. In making the initial selection the individual plant was carefully studied in each case and the various characteristics were noted. Among others, the selections included eight of Earliana, thirteen of Chalk Jewel and eight of Matchless. Twenty-two plants were planted of each selection in the field, but records were kept of the twenty inside plants only, the end plants being eliminated in all cases in order that each plant studied have environmental conditions as nearly uniform as possible. It may be conceded at this time that the number of plants used is too few to obtain the most satisfactory experimental results, but there is a limit to the number of plants which may be handled and properly studied and it was thus conceded that in the early stages of the experiment, it was preferable to use a larger number of initial selections and later in-

crease the number of plants to be studied of the strains which proved most promising.

In securing the data for this experiment, each plant was numbered and at the various pickings the fruits were recorded with respect to number, grade and weight. As the season progressed it was observed that in some instances the general character of the fruit of a particular strain was not so good as that of the parent, while in other instances it was equally as good, and in some others it appeared to be somewhat improved. A test of these the subsequent season indicates that while the plant should be considered the unit of selection and that in selection work we should expect to find in the progeny those characters which are present in the parent, yet it may not necessarily follow in all cases since in some the superiority may be due to environment and not to heredity, a fact which can be proved only by subsequent breeding tests. It is doubtless true that in many instances the unsatisfactory results and subsequent lack of interest in the subject by persons who first engage in plant improvement, may be attributed to this factor.

It has been previously mentioned that in some instances certain strains show superiority from the beginning. In some instances one or more plants appeared superior to the average of the test, and of these seed was secured with which to make subsequent tests. It is the study of these parent plants and their progeny in which we are primarily interested in the present discussion.

In this study we have used the statistical method* as being the best suited to the problem. As previously intimated the number of plants studied is doubtless small, but we are of the opinion that the results secured may be considered as fairly representative of a larger population.

In order that the work could be compared with commercial seed, checks have been used and the behavior of the respective plants studied along with that of the selection. In each instance the strain used for the check was the best obtainable as proved by the strain tests and doubtless represented the best commercial seed procurable through the regular channels. In the present discussion, we deal only with the variety Earliana. The records, as regards weight of fruit of the various selections together with those of the check strain, are shown in the following table:

*Davenport, Eugene—Principles of Breeding, p. 419-452. Ginn & Co., 1907.

EARLIANA—WEIGHT OF FRUIT.

Record No.*	Year	Number of Plants	Mode Grams	Mean Grams	Standard Deviation	Coefficient of Variability	Modal Coefficient
Check	1912	53	4500	3801 ± 113	1224 ± 80	32% ± 2	26%
Check	1913	79	2500	3816 ± 112	1475 ± 79	39% ± 1	34%
Check	1914	99	5500	5368 ± 124	1834 ± 88	34% ± 2	24%
1-	1912	13	3500	4115 ± 173	924 ± 122	22% ± 3	46%
1-	1913	20	4500	5050 ± 221	1465 ± 154	29% ± 3	30%
1-	1914	20	5500	5700 ± 247	1638 ± 175	28% ± 3	30%
1-12	1913	18	4500	5500 ± 309	1494 ± 218	35% ± 3	22%
1-12	1914	20	5500	4800 ± 197	1307 ± 139	27% ± 3	30%
1-12-12	1914	20	6500	5400 ± 213	1410 ± 150	26% ± 3	35%
3-	1912	20	5500	5450 ± 276	1830 ± 195	34% ± 3	35%
3-	1913	33	5500	5984 ± 181	1543 ± 227	26% ± 4	24%
3-	1914	20	5500	5950 ± 154	1023 ± 109	17% ± 2	35%
3-18	1913	40	5500	6175 ± 113	1058 ± 80	17% ± 1	40%
3-18	1914	20	4500	5050 ± 175	1160 ± 115	23% ± 2	35%
3-18-26	1914	19	5500	5289 ± 119	769 ± 84	14% ± 2	68%
4-	1912	19	3500	3605 ± 122	788 ± 86	2% ± 2	37%
4-	1913	20	4500	4800 ± 159	1053 ± 112	22% ± 2	35%
4-15	1913	19	3500	4026 ± 146	943 ± 103	23% ± 2	42%
4-15	1914	20	5500	5500 ± 178	1183 ± 126	21% ± 2	30%
4-15-17	1914	20	5500	5150 ± 153	1013 ± 108	15% ± 2	45%
40a-	1912	20	3500	3200 ± 166	1100 ± 117	34% ± 2	30%
40a-	1913	15	4500	4033 ± 147	884 ± 104	21% ± 3	40%
40a-	1914	20	5500	5000 ± 226	1500 ± 160	30% ± 3	30%
40a-15	1913	20	4000	4000 ± 154	1024 ± 109	25% ± 3	30%
40a-15	1914	15	5500	5766 ± 226	1528 ± 188	26% ± 3	26%
2a-15-4	1914	20	3500	4850 ± 249	1651 ± 176	34% ± 4	35%
2a-15-4	1914	20	4500	4600 ± 178	1178 ± 126	25% ± 3	35%

*The system of numbering used in the experiments is that proposed by Dr. H. J. Webber and described by him in Bailey's "Plant Breeding," pp. 308-310. Briefly stated, the first number is that given to the plant when the initial selection was made. The numbers which follow are selections of the respective plants in successive generations. Where a small letter appears, it indicates that the selection was made for a special purpose.

The terms mode, mean, standard deviation, coefficient of variability and modal coefficient are the recognized statistical constants, and may be briefly defined as follows:

Mode is that class into which most of the individuals fall. It is the best obtainable single expression for type.

Modal coefficient is the percentage of the population which falls into the modal class, and is an index to the relative conformity to type.

Mean is the product of each value by its frequency divided by the total population. It is a conception of type.

Standard deviation is a measure of variability and shows the variation of the population from the mean and is useful in comparing the variability of one population with that of another with respect to the character under consideration.

Coefficient of variability. This is an abstract expression which combines the idea of standard deviation and of type, in which the variability appears in the form of rate per cent.

For method of determination of these constants, the reader should consult the reference cited in Principles of Breeding.

In the above table we have determined the accepted statistical constants of mode, mean, standard deviation, coefficient of variability and modal coefficient. For the benefit of those not familiar with statistical work, it may be said that from the standpoint of the breeder who desires to secure a uniform strain, he aims to secure a high mode, mean and modal coefficient and relatively low standard deviation and coefficient of variability. With these points in mind, we may consider the above results somewhat in detail. Before deducting any conclusion, however, it should be borne in mind that seasonable conditions exert considerable influence, and the season of 1914 was generally considered unfavorable to the tomato crop.

The low coefficient of variability of series 4-1912 may be by some considered as an error. It is not. The plants for the season were particularly uniform, the weight of fruit of all falling into three consecutive classes.

For the check strains the same lot of seed was used in years 1912 and 1913, while for 1914 a different lot was used.

A study of the table shows that in almost every instance the mode, mean and modal coefficient in the check strain were the same as or even less than in the selection, while the variation as indicated by the standard deviation and coefficient of variability was correspondingly greater.

A study of the various strains tested, as well as the subsequent selections, shows that while in general the selections are superior to the commercial strains, yet in not all cases do they show consistent gains, although in some they do. A study of 1- and its subsequent selections is of interest. It will be seen that for the past season the mode and modal coefficient were greater in the third selection, and the standard deviation and coefficient of variability

were smaller than for the parent; likewise differences of interest may be noted with respect to other strains.

A study of 3- and its progeny for the past season shows that the mode has remained practically stationary while the modal coefficient has been increased in the third generation from 35 to 68 per cent; likewise there has also been a considerable decrease in the standard deviation and coefficient of variability.

A study of Series 4-15 and the selection from it, 4-15-17, for the year 1914, shows similar results, while a study of Series 40a- and its progeny shows rather indefinite results. Strain #3 is of interest since it is probably the best bred strain of Earliana which is sold commercially. It sells for \$5.00 per ounce and in comparison with other strains on the market it is well worth the money; however, a comparison of this series with 4-15-17 shows that the limit of perfection has not yet been reached. The next table shows the constants for the average weight of fruit.

EARLIANA—AVERAGE WEIGHT OF FRUIT IN GRAMS.

Record No.	Year	Number	Mode Grams	Mean Grams	Standard Deviation grams	Coefficient of Variability	Modal Coefficient
Check	1912	53	145	140 ± 2	22 ± 1	15% ± 1	33%
Check	1913	79	105	100 ± 1	14 ± 1	14% ± 1	26%
Check	1914	99	75	84 ± 1	17 ± 1	20% ± 1	27%
1-	1912	13	145	145 ± 4	16 ± 3	11% ± 2	30%
1-	1913	20	105	105 ± 3	20 ± 2	19% ± 2	25%
1-	1914	20	75	79 ± 2	13 ± 2	16% ± 3	55%
1-12	1913	18	105	102 ± 3	18 ± 2	17% ± 2	33%
1-12	1914	20	85	82 ± 1	9 ± 1	10% ± 1	40%
1-12-12	1914	20	65	73 ± 3	22 ± 2	30% ± 3	45%
3-	1912	20	125	135 ± 5	34 ± 4	25% ± 3	45%
3-	1913	33	95	102 ± 3	22 ± 2	21% ± 2	30%
3-	1914	20	65	80 ± 4	25 ± 3	31% ± 4	50%
3-18	1913	40	95	97 ± 4	26 ± 2	26% ± 2	32%
3-18	1914	20	65	82 ± 4	29 ± 3	35% ± 4	50%
3-18-26	1914	19	75	81 ± 4	26 ± 3	32% ± 4	42%
4-	1912	19	145	137 ± 2	16 ± 2	11% ± 1	42%
4-	1913	20	105	101 ± 3	18 ± 2	17% ± 2	30%
4-15	1913	19	105	98 ± 3	17 ± 2	17% ± 2	52%
4-15	1914	20	85	93 ± 2	16 ± 2	17% ± 2	35%
4-15-17	1914	20	95	92 ± 2	11 ± 1	11% ± 1	25%
40a-	1912	20	115	127 ± 2	15 ± 2	11% ± 2	35%
40a-	1913	15	115	107 ± 2	10 ± 1	10% ± 1	40%
40a-	1914	20	75	81 ± 2	13 ± 1	17% ± 1	35%
40a-15	1913	20	115	108 ± 2	14 ± 2	16% ± 2	40%
40a-15	1914	15	85	87 ± 2	12 ± 1	13% ± 1	40%
40a-15-4	1914	20	85	87 ± 2	13 ± 1	15% ± 1	50%
#3	1914	20	90	90 ± 1	9 ± 1	10% ± 1	35%

AVERAGE OF TEST OF EARLIANA.

Record No.	Average Weight per Fruit—Pound.	Yield per acre to Sept. 2. Tons	Yield per acre to Sept. 12. Tons	Corrected Yield per Acre. Tons	Per cent Marketable.
Check ²	.28	9.73 ¹	11.04	11.43	83
Check	.18	9.03	13.03	15.75	88
1- ³	.25	12.09 ²	13.49	14.55	88
1-12 ²	.21	11.17	13.71	14.37	93
1-12-12	.16	9.02	13.32	15.23	90
3- ³	.22	12.94 ²	15.03	16.75	87
3-18 ²	.20	11.75	15.48	16.21	91
3-18-26 ¹	.17	7.83	12.83	16.87	95
#3	.20	7.37	11.66	15.25	95
4- ²	.27	12.65 ¹	11.99	12.93	86
4-15 ²	.21	9.63	11.72	14.40	92
4-15-17 ¹	.20	8.78	12.24	14.60	96
40a- ³	.24	8.91 ²	9.92	11.89	85
40a-15 ²	.22	9.22	12.11	14.21	89
40a-15-4 ¹	.19	7.68	11.88	13.65	97

In the above table the yield is given at different dates as a means of determining the earliness. The corrected yield per acre is the total yield for the season, after having been corrected for possible differences of soil fertility as was shown by the yield of the check strains. It is the opinion of the writer that it most nearly represents the yielding property of a strain. For method of determination see Report of The Pennsylvania State College, 1911-12.

The small figures above and to the right of the numbers indicate the number of years the test was made, the numbers representing the average for the period. Where no indices appear, the value is that given in the first column for the respective strains.

A study of the above table shows that the average yield of the check for two years to September 2 has been nine tons per acre, while that of 1- gives an average yield for the two years to the same date of more than 12 tons per acre, and there has also been a corresponding increase in the total productiveness. With regard to the same strain, it will be seen that the yield of strain 1-12-12 as regards earliness is not as good as the average of 1-, but this is possibly due to seasonal conditions. It will be noted that the same is true in most of the other strains as regards earliness while the yields for the latter part of the season have, in some cases, been increased as well as has been the percentage of marketable fruit. A comparison of strain #3, to which attention has previously been called, with several of the selections shows that it is not superior.

The present paper may be considered as a report of progress rather than one of definite conclusions. Sufficient time has not elapsed to secure satisfactory results on the much discussed question of the effect of selection within pure lines, if tomatoes may be

considered as coming in this classification; however, the data presented seemed to indicate the feasibility of improving this crop by careful selection.

The above table is of interest in that it shows the influence of selection within the same line with respect to size of fruit. As in the previous table the record for the check strains is also given. It will be seen that the mode of the selections compares favorably with that of the check strains, while the modal coefficient is generally larger, and the variability in each case is practically the same. A closer analysis of the constants shows that in most instances there has not been a decrease in the size of fruit because of selection as is sometimes supposed, while in the majority of instances there has been an increase which is sometimes accompanied by a correspondingly high modal coefficient, thus showing a definite improvement with respect to this character.

In the last table, the selections are studied from the standpoint of the commercial gardener who is primarily interested in securing a variety which matures early and is productive.

DECEMBER 29, 1:30 P. M.

The meeting was called to order by President Corbett.

COURSES IN SYSTEMATIC VEGETABLE GARDENING.

By PAUL WORK, *Cornell University, Ithaca, N. Y.*

Two years ago the attention of this Society was called to a paper on the teaching of vegetable gardening. It was shown that the vegetable gardening industry had grown until the value of its products exceeds that of all other horticultural products combined. It has been the aim to build up at Cornell a series of courses to meet as fully as possible the requirements of this great industry. At that time a scheme was proposed which, it was thought, would fulfill the needs of the amateur, or the non-specializing student who may be interested in commercial production, and of the man who wishes to become a specialist in vegetable gardening. The plan doubtless appeared rather visionary to most of the members of the Society at that time, and it was proposed with some slight misgivings as to the probability of its immediate adoption. However, the scheme was placed in effect the following year. The adoption of a third or summer term which is fully commensurate with the fall or spring terms has made possible a further improvement which was not anticipated two years ago. The specializing student now spends his first year in the usual fundamental courses and his first vacation on a farm. His elementary work is continued in the first term of his second year, after which he goes to a commercial vegetable farm to spend the next two terms, a full growing season from February to September. This is considered important not only for city students but also for those who have been brought up on vegetable farms,

for few places offer experience as varied as is desirable. One who is well grounded in the practice of the business is indeed in a position to gain even more from a study of methods which are new to him. He has a background against which he may make comparisons.

The specializing student begins his vegetable studies in his fifth semester, in February of his third year, with a course which deals with general outdoor production and which continues from that time until September. He assumes full responsibility for his own plantings from seed time to harvest. Parallel with the second half of this course he takes a course in systematic vegetable crops, the subject of this paper. He spends the next term away from the college. In the following spring term he takes vegetable forcing and Course 7, which is an introduction to the investigational side of the subject. The research that has been accomplished is reviewed, and each member of the class selects a problem to be studied by review of the literature available and by means of a simple field test which may be continued through the summer term. Thus his graduation is delayed from June till September. In advising students as to the selection of courses, special emphasis is laid upon the necessity for well rounded training in agriculture, both in fundamental subjects such as soils, botany, and plant physiology, in such subjects as plant pathology, entomology, and plant breeding, and also in the other phases of horticulture and agriculture, as pomology, floriculture, farm crops, and animal industry. The following scheme of courses is in use at Cornell:

SCHEME OF COURSES FOR STUDENTS SPECIALIZING IN
VEGETABLE GARDENING AT CORNELL.

	<i>Fall Term</i>	<i>Spring Term</i>	<i>Summer Term</i>
<i>First year</i>	In college	In college	Field experience
<i>Second year</i>	In college	Field experience	
<i>Third year</i>	In college	In college Elementary Commercial Vegetable Gardening Systematic Vegetable Gardening	
<i>Fourth year</i>	Experience	In college Vegetable Forcing Undergraduate Research	

Most vegetable gardening teaching hitherto has fallen short in that the student has learned a great deal about vegetables, but has not acquired a sufficiently intimate acquaintance with the plants themselves. Those of our graduates who expect to farm do not know the plants and the varieties well enough to choose or even to test out intelligently for their own operations. They hardly know what to look for. Too many of us who are engaged in scientific work are not able to converse on even terms with the observing gardener whose knowledge of the sorts which he handles is pretty thorough, but whose acquaintance is usually rather narrow, and I believe we shall all have to confess to a grave deficiency when we compare notes with the better informed men of the seed trade.

A number of factors are at work in bringing about a better acquaintance on the part of the students. We find in our colleges a larger number of boys of good field experience. Those who lack in this respect realize the need and are using their vacations to make it good. General laboratory work is today planned in such a way as to bring a student into more intimate contact with the plants than ever before. Teachers are themselves studying varieties and strains more carefully.

The problems involved in the study of types and varieties of vegetables are more difficult than appears at first. We naturally compare with the same type of work for fruits, but we soon realize that annual and biennial plants change in characters a great deal more quickly than perennials. The Earliana tomato today is quite different from the Earliana of five or ten years ago, and the Grant is no longer catalogued. One stock of Golden Selfblanching celery differs materially from another, and the practice of seedsmen leads toward, rather than away from, confusion. No recognized authority exists, and no recent work such as Vilmorin or Burr is available. These difficulties, no matter how serious they may be, should not deter us from giving careful attention to the subject. No progress can be made without this attention. To accomplish such progress the combined influence of well directed thoroughgoing research, of organized effort toward standardization and of well planned courses for the systematic study of vegetable crops, are necessary. Time will not permit us to touch upon the revival of taxonomic research from the oblivion into which it fell after the widespread effort which was devoted to it in the early days of the experiment stations, nor upon the possibilities of such work as is being undertaken by the Vegetable Growers' Association of America looking toward the establishment of some form of clearing house that may be recognized as authority in matters of this sort.

We have spoken of the usefulness of an intimate knowledge of standards of excellence for types and varieties and strains. No less to be considered is the essential educational value of studies in systematic science. The faculties of observation, discrimination, evaluation, classification, and comparison may be developed and trained as satisfactorily in this type of courses as in the taxonomic work of our botany departments and much more thoroughly than in

our ordinary general crop courses. Our teaching ideal has changed so that we no longer strive to fill a student with information, but we strive rather to use information as material by which a student may learn to solve problems and meet situations as they arise. It can hardly be doubted that systematic courses offer splendid possibilities in this direction.

As offered at Cornell, the course in systematic vegetable crops calls for one lecture and two laboratory periods throughout the summer term. One of the general vegetable courses must precede it, and for these work in soils and botany is, in turn, prerequisite. The lectures take up first the scope of the subject and its relation to garden craft and garden science. The work of the systematic student is defined as the gathering, preserving, and dissemination of knowledge of the characteristics of vegetable plants as distinguished from knowledge of their requirements, culture, and the like.

Next are discussed the principles underlying the various phases of such studies, namely, description, including characterization and evaluation, nomenclature, classification, identification, and judging.

The material of the laboratory work is the plants themselves and is based upon a garden which includes the leading varieties and some of the strains of all the vegetables. This plot is laid out in blocks with the various plantings of a given vegetable placed side by side. It is under irrigation and is provided with ample paths for convenience in observation. Labels for this coming year are to be done in India ink on cards dipped in paraffin and tacked on stakes.

Two problems present themselves in connection with these gardens: first, how to determine which type of a given variety is correct, and, second, how may a scheme of planting dates be arranged to insure a proper succession of crops for study in laboratory periods throughout the term.

The laboratory exercises include four types of work:

First.—Description. For this purpose sheets to be filled chiefly by underscoring are provided. One or two varieties are run through, instructor and class working together and giving special attention to the meanings of terms used. Then each student fills out sheets for several additional sorts. Drawings are placed on the back of the sheet.

Second.—Characterization and Evaluation. Under remarks the student prepares from his observation and the raw data of the description sheet a readable paragraph setting forth the main characteristics of the sort and indicating its strong and weak points.

Third.—Identification. At the close of the period and on later laboratory days, specimens are arranged side by side for comparative study and identification.

Fourth.—Judging. Practice in judging is provided in connection with the laboratory work, and a required trip to the New York State Fair at Syracuse offers additional opportunity in this direction.

Special emphasis is laid upon the preparation of a term paper on one of the vegetable crops. Catalogues, periodicals, and books are

searched for information, and a bibliography is prepared. A test of eight or ten varieties of the selected vegetable is planted, established and cared for. The student devises his own description sheet and makes the necessary record. His final report follows the general outline which is used in the lectures. Thus the student gains an introduction to the methods of systematic research. The following is a sample of the descriptive blanks used:

LETTUCE AND ENDIVE.

Described by.....

Date.....

VARIETY SOURCE

TYPE: Loose leaf, head, cos; Endive; Escarolle; butter, crisp.

DATES: Planting:; Cuttings: 1st..... Main..... Last.....

GROWING CONDITIONS: soil.....; Season.....

PLANT: Vigor..... Habit: Erect, spreading, compact, open.

Size: Spread in.; height in.; weight oz.

Proportion of outer to head leaves.....

Stem: short, long. Much, little diseased; how.....

Resistance to heat; to frost; to drouth

Becomes usable quickly, slowly. Shoots to seed quickly, slowly.

LEAF: Width in. Thick, thin. Form—make drawing on back.

Color: tinged with; dull, glossy.

Surface: Flat, curved; smooth, savoyed, crumpled, waved.

Margin: entire, serrate, crenate, scalloped.

Veins: Midrib prominent, not; Veining fine, coarse.

MARKETABLE HEAD OR BUNCH: Size . . . in. wide in. deep.

Form—make drawing on back.

Compactness Bleaching: self, not; color

Quality Texture: tender, tough

Flavor: bitter, sweet.

STOCK: true, not. Variety distinct, not. . . % sprouted.....

ADAPTATION: suited, not for forcing, garden, market, storing.

REMARKS:

REQUIRED TRIPS FOR HORTICULTURAL STUDENTS.

By F. N. FAGAN, *Pennsylvania State College, State College, Pa.*

I do not wish to pose as the originator of the required inspection trip of the junior horticultural students of the Pennsylvania State College. The idea is the result of a great deal of thought on the part of our former Dean, Thomas Hunt, and Professor R. L. Watts.

Prior to the summer of 1913, the junior horticultural students at our college were required to spend at least six weeks working on commercial horticultural farms. Then during their senior year they wrote a report of the farm and its operations, including, as far as possible, all detail work of the farm and a financial statement as to cost of production, sale price, marketing cost and profits.

It was found in many cases that the students often were not engaged in the true horticultural work on these farms and were really not getting a great deal of information along the desired line. During their entire stay on these farms, they often hoed, made hay, cultivated, worked roads, etc. In other words, they were given one job practically the entire summer. I readily see the farmer's side of this student labor question, for it is not good management on his part to be switching men from one job to another simply because a man wants the experience.

For the above reasons the summer work was changed to an inspection trip to be conducted under the direction of one of the department staff. The original plan outlined by Messrs. Hunt and Watts was to make arrangements with different fruit growers, vegetable forciers, truck gardeners and florists, located in some fairly accessible location, to take our students to their property and to have them work the same as laborers for a few days, doing whatever work these growers had on hand, such as thinning apples or peaches, cultivating, hoeing, spraying, washing vegetables, and preparing flowers and produce for market.

Having a wide experience with commercial men and being possibly more practical than scientific myself, I at once doubted the success of such a plan and on taking it up with the growers, I found that they confirmed my belief. I thus changed the plan to that of pure inspection and on that basis have conducted two inspection trips. That of the summer 1913 with 17 students and of 1914 with 24 students.

Western New York and Northern and Northwestern Pennsylvania, were selected for these inspection trips because these are sections where all the different horticultural lines of our temperate climate could be seen with a minimum amount of travel. The itinerary of 1914 is as follows:

Erie, Pennsylvania, to inspect vegetable forcing and cut flower production.

Northeast Pennsylvania, to see the extensive grape and small fruit industry, together with peaches, pears, plums and some apples, and also the manufacturing of grape juice.

Fredonia, New York, to visit the small fruit nurseries and the New York Vineyard Laboratory, where some very valuable information was received.

Angola, New York, where the extensive commercial berry industry was at its height. Berries are grown here for the canneries and for dessert use.

Medina, Lockport, Alcott, Hilton, Williamson, and Geneseo, New York, where are large plantings of cherries, plums, peaches, apples, and standard and dwarf pears.

Rochester and Dannsville, New York, to see the nurseries, park plantings, home landscape gardening, and three types of cold storage plants.

Irondequoit and Williamson, New York, where the vegetable forcing and trucking are different from that at Erie, Pennsylvania. A

side trip to the Experiment Station at Geneva proved highly instructive.

Enroute over the entire trip we inspected barrel and basket factories, canning plants and public markets.

Our plan has worked out successfully because in nearly all cases the owners have made it a point to be on hand to welcome us and have taken time to show and explain in detail their operations, giving freely their failings and successes, costs and labor problems. Without their willing support our inspection trips would have been total failures. The trips have covered a total of about 700 miles, not including the travel by trolley and livery rigs.

The kinds and number of places visited are as follows: Fruit farms 18, vegetable forcing and trucking 12, flower growing 9, seed farms 1, nurseries 14, parks 5, canning and evaporating houses 3, spray machinery 1, greenhouse firms 1, basket and barrel factories 3, cold storages 3.

The above was accomplished in about twenty-eight or thirty working days at an average expense of eighty to one hundred and thirty dollars per man.

The total number of business men visited and consulted was seventy. Each grower was found to have different problems to solve, such as soil conditions, cultural methods, harvesting and marketing, insect and fungous troubles, etc. In most of the cases they have been solved in somewhat different ways. These points have been brought out by questions asked by the students and generally the answers have been placed in their notes. At the end of such a trip the student has not only stored much information in his mind, but has placed a much larger amount in his notes.

The enthusiasm shown by different growers in pointing out their operations, awakens an interest in the student which cannot be produced in the class room or laboratory. The contact with so many different growers broadens the student wonderfully.

The most convenient times for making these trips are late June and early July or late August and early September. The first part of the summer seems to be best because county fairs and summer meetings are not so likely to entice the growers from home, as is the case later in the season.

To receive the six credits allowed for this summer work, the student must submit during the first half of his senior year a typewritten report of the trip. The average report contains about 12,500 words.

The grade given is based upon promptness at the hour set for the beginning of each day's work, attitude and conduct on the trip, interest shown, and the completeness of the report.

One important feature of such a trip from the teacher's viewpoint is the fact that he can become intimately acquainted with the students.

Such an extended trip is not necessary in every agricultural college curriculum, for some colleges are so fortunately located as to have all the industries at their very doors; but situated as we are

at State College, Pennsylvania, away from all horticultural plantings and business enterprises, we believe such an inspection is nearly as valuable as one-half year of college work, especially is this true in the practical courses.

REPORT OF THE COMMITTEE ON FLORICULTURAL COURSES.

BY A. C. BEAL, *Cornell University, Ithaca, N. Y.*

Floriculture is often considered a new subject in the horticultural curriculum. In so far as the work catches the spirit of modern commercial floriculture, it is a new subject. At the same time we need to recognize that for many years work has been given in many, if not all, of our agricultural colleges which had a direct application to greenhouse work. The instruction in plant propagation and handicraft contained much of value to future florists.

The history of floricultural teaching would make an interesting chapter in our horticultural history if it could be written. When one attempts to do this he is confronted with difficulties due to the great variation in the standards of the different colleges. In some of the early catalogues it is stated that work in horticulture consists of an enumeration of topics often ranging through the whole gamut of horticulture. Although floriculture was sometimes mentioned, it is difficult to even approximate the attention given it among the many other topics.

The first floricultural courses, as we understand a course or subject, was offered in the School of Horticulture of the Illinois Industrial University in 1875-1876. These courses are so definitely stated that they could almost be transferred to a modern college catalogue. The courses, which are interesting historically, were as follows:

"Floriculture. Fourteen weeks are occupied in the study of the kinds, propagation, growth and care of flowering and other ornamental plants. Each student has practice in propagating by cuttings and otherwise, in potting and shifting, and care of plants requiring various treatments. Insects and diseases with remedies are thoroughly treated, and the means of securing vigor of growth or abundance of flowers, are studied and illustrated by practice."

Among the reference books the following are important: Henderson's Practical Floriculture, Loudon's Encyclopedia of Plants, Parkman's Book of Roses.

"Plant Houses and Management. The work this term is upon garden and landscape architecture, the methods of construction, heating and ventilation, and general management so as to secure under the different circumstances the best plant growth. The classroom work consists of lectures and architectural designing and drawing. Illustration and practice are afforded by the plant houses of the University, and by such others as can be reached by class excursions."

"Landscape Gardening. Eleven weeks are devoted to this study. Lectures are given upon the general principles of the art, the his-

tory and styles, the kinds and use of trees, shrubs, grass and flowers, the introduction and management of water, the construction and laying out of drives and walks, fences, buildings, etc. The class draw first from copy, then after the actual study of some locality with its environments design and draw full plans for its improvement, indicating position of all prominent objects, including kinds and groups of trees and other plants. These plans with specifications are to be deposited in the library of the school. Excursions are made as found practicable for the study of public and private grounds."

Important reference books are Downing's *Landscape Gardening*, Weidemann's *Beautifying Country Homes*, Robinson's *Parks, Promenades and Gardens of Paris*.

Since the above courses were an integral part of a four-year program they were undoubtedly given, and the writer believes them to have been the first definite courses in ornamental horticulture given in America. Later it appears that the four-year course was given up and with the free election of courses, the floricultural course, as such, was dropped. The course in greenhouse construction was retained. In 1900 a course in commercial floriculture was offered which was the first course intended to teach those principles underlying commercial cut-flower production. In 1902 a course in amateur floriculture was offered. These attempts at Illinois led to the recognition of the Department of Horticulture by the commercial florists of the state who were instrumental in securing from the state the magnificent equipment the University of Illinois now has for experimental work under glass.

During all of the period prior to 1900 the instruction in floriculture or related subjects was given by the professors of horticulture or their assistants. When instruction in floriculture was first given by practical florists, it is impossible to discover. In many cases names of gardeners and florists appear on the college faculties or upon the staff of the experiment stations. In some cases these persons may have given instruction; at least we may be certain that they did assist in all handicraft courses. The graduates of Michigan and Cornell have filled most of the horticultural positions, and the success of these men in teaching greenhouse and garden handicraft is due in a considerable degree to the training they received from Messrs. Gunson and Hunn.

Meanwhile the business of floriculture was developing rapidly. In fact, no branch of horticulture has made more rapid progress since 1885. About 1900 the colleges began to recognize that floriculture was a highly specialized industry requiring trained men to present the subject adequately to students.

The first instructorship in floriculture was established at the Michigan Agricultural College in 1901, followed by Illinois and Massachusetts in 1903. Massachusetts created the first assistant professorship in 1907, and this later became the first professorship in 1908. Other assistant professorships established were at Illinois in 1911, Cornell in 1911, and Maryland in 1912.

While Illinois was the first to adopt the principle of specialization and to give a commercial course which won early and substantial recognition from the florists, and while Massachusetts was the first to dignify the subject by giving it professorial rank, it remained for Cornell to take the most far-reaching step. This was the creation of a separate and distinct department of floriculture co-ordinate with any departments of the college and responsible only to the dean and director. The department now has two professors, one assistant professor, three instructors and one assistant giving instruction and carrying on investigations in floriculture. Instruction is given to regular students twelve months in the year with short courses during the winter and again in summer. Thus Cornell, which did not have any floricultural course until 1909-10, although greenhouse construction had been taught since 1895, became first in its recognition of floriculture.

Last year your committee outlined several floricultural courses which it again recommends.

For some years it is probable that those students desiring thorough or extended special instruction in floriculture will attend those institutions which have definitely organized departments or sub-departments of floriculture under trained specialists. This committee therefore urges that attention be given to courses in the growing of flowers in and about the home, plant propagation, and greenhouse construction. With these as a foundation, other courses may be added as the work and the interest develop.

Equipment. For thorough instruction in floriculture an up-to-date greenhouse or range of greenhouses is necessary. The houses should be such as a live commercial florist would build. It is a fact that some institutions which have a small appropriation for greenhouses have made the mistake of spending the larger part, or at least an undue proportion of it, for a conservatory. The latter is expensive to build and also expensive in money or time, or both, to properly maintain. We believe that a department with a small maintenance fund is fortunate if it does not have a large conservatory. A good range of growing houses, even though small, are infinitely more useful for instruction and investigation. Such a range well kept and showing evidence of practical instruction will do much to gain the interest and sympathy of the florists. The purpose should be to give training in the fundamental principles of plant growing under glass to students who have had training in botany, plant physiology and soils. Later there will doubtless be a demand on the part of the students for advanced work in floriculture, and then a conservatory will prove useful in affording material for study.

The laboratory instruction should be practical and with living plants as far as possible. For this reason summer courses should be given to acquaint the students with outdoor flowers. Species and forms not possible to have growing each year may be shown by herbarium specimens and illustrations. Good lantern slides of specimen plants and flowers, also showing different floricultural oper-

ations and forms of greenhouse construction, are a necessity. Many commercial firms will send catalogues, models, photographs and blue prints to those who will make use of them in instruction.

Last, but not least, a select library of good floricultural books is required. The books really worth while as reference books for undergraduates are not very numerous nor would their total cost be a serious burden. In addition the students should have access to one or more of the trade papers and also to the garden papers like *Garden Magazine*, *Country Life in America* and the *Countryside Magazine*.

A teacher of floriculture should get into touch with the practical men to gain their sympathy and support. The college man should attend the meetings of florists and visit their greenhouses. Some of the florists will take an interest in everything the college is trying to do for floriculture and will be willing to help. The colleges can well afford to consult the practical men before building a range of glass, but the experienced instructor can better advise as to the instructional needs. The florists in every state will look to the colleges more and more for help to solve their problems, and the institutions that can appreciate their needs and which are trying to serve their interests in the best possible way with the existing facilities, will find loyal supporters in building up college and station work in floriculture.

REPORT OF COMMITTEE ON SCORE CARDS.

W. II. ALDERMAN,

Chairman, Experiment Station, Morgantown, W. Va.

Upon the matter of score cards your committee has a very brief report to make. Last year the score cards presented to the society by your committee were accepted for one year's time with the understanding that they be finally accepted or rejected at this meeting. In order to ascertain with what favor the cards had met, the chairman a few weeks ago sent a circular letter to all the horticulturists of the country, that is, to the heads of the horticultural departments, asking for suggestions or criticisms. Out of the several replies only fourteen expressed opinion one way or another. Of these ten expressed approval of the cards as they now stand, or practically so, and four contained minor suggestions such as changing the words "freedom from blemish" to "condition", or of altering slightly the values given to some factors. Inasmuch as these suggested alterations in no wise agreed with each other, and in some cases actually conflicted, your committee was at a loss how to act. Since no sweeping changes were suggested, and since we will probably never be able to entirely agree upon some of the minor matters, your committee recommends that the score cards be permanently adopted as they stand.

Some of you will remember that another matter was entrusted to this committee, namely, to determine the ideal sizes for exhibition purposes of the several varieties of apples grown in the United States and Canada. After spending most of the year in a fruitless discussion as to the best method of attacking the problem, it was decided best to divide the work and let Professor Macoun collect the data for Canada, and Professor Sears and myself for the United States. Circular letters were sent to the Horticulturist of each experiment station and to the Professor of Horticulture of each college of agriculture in the country. In addition to this, about eighty letters were sent out to growers and commission men. Twenty-six replies were received from the professional horticulturists, sixteen from the growers, and seventeen from the dealers. The horticulturists were asked to report upon the varieties succeeding best in their state. Out of the twenty-six, ten were unable to furnish any information. From the other sixteen, and from the premium list of the New England Fruit Show, the data in table I covering 121 varieties, was secured. The summary which represents the findings of the committee is not an average of all reports, but represents rather the mode or type as expressed in the reports. In a few cases where a variety was reported from a region in which it obviously did not develop to its best, the report was partially or wholly ignored.

TABLE I.
IDEAL SIZES OF EXHIBITION APPLES, DIAMETER GIVEN IN INCHES.

Variety	New England Fruit Show	Maine	Indiana	Ohio	New Jersey	Virginia	Illinois	New York	Montana	New Mexico	Wisconsin	Maryland	Delaware	Nebraska	Idaho	Iowa	W. Virginia	Summary
Akin	3 3/8-3 3/4		2 3/4-3 1/4									2 1/2-3					2 1/2-3 1/4	2 1/2-3 1/4
Alexander	3 3/8-3 3/4	3 3/8-3 3/4										3	3 1/2-3 3/4	2 3/4-3		3-3 1/2	3 1/2-3 3/4	3 1/2-3 3/4
Arkansas					3-3 1/4	2 3/4-3 1/4				2 1/2-3		3		2 3/4-3	3 1/2-3 3/4	2 3/4-3 1/2	2 3/4-3 1/2	2 3/4-3 1/2
Arkansas Black										2 1/2-3	2 1/2-3						2 3/4-3 1/2	2 3/4-3 1/2
Babbitt																	2 3/4-3 1/2	2 3/4-3 1/2
Bailey	2 1/2-3 1/4													2 3/4-3			2 3/4-3 1/2	2 3/4-3 1/2
Baker	3 1/4-3 1/2														2 1/2-3 1/4		3 1/2-3 3/4	3 1/2-3 3/4
Baldwin	3-3 1/4	3-3 1/4	2 1/2-3 1/4	3 1/4-3 1/2	3-3 1/4			2 3/4-3				2 3/4-3					3 1/2-3 3/4	3 1/2-3 3/4
Baltimore				2 1/2-3 1/4													2 3/4-3 1/2	2 3/4-3 1/2
Beach																	2 3/4-3 1/2	2 3/4-3 1/2
Belmont				2 1/2-3 1/4													2 3/4-3 1/2	2 3/4-3 1/2
Ben Davis	3-3 1/4	3-3 1/4	2 1/2-3 1/4	3-3 1/4		2 1/2-3	2 3/4-3					3-3 1/4		3-3 1/4	2 1/2-3 1/4	3-3 1/4	3-3 1/4	3-3 1/4
Bietighelmer	3 1/4																3 1/4-3 1/2	3 1/4-3 1/2
Black Ben Davis				3-3 1/4						2 1/2-3					2 1/2-3 1/4		3 1/4-3 1/2	3 1/4-3 1/2
Black Gilliflower	2 1/2-3 1/4																2 3/4-3 1/2	2 3/4-3 1/2
Blenheim	3 3/8-3 3/4																3 3/8-3 3/4	3 3/8-3 3/4
Blue Pearmain	3-3 1/4	3-3 1/4															3-3 1/4	3-3 1/4
Canada Reinette	3 1/4-3 1/2																3 1/4-3 1/2	3 1/4-3 1/2
Chenango	2 3/8-2 3/4																2 3/8-2 3/4	2 3/8-2 3/4
Collins														2 3/8-2 3/4			3-3 1/4	3-3 1/4

TABLE I.—(Continued.)
IDEAL SIZES OF EXHIBITION APPLES, DIAMETER GIVEN IN INCHES.

Variety	New England Fruit Show	Maine	Indiana	Ohio	New Jersey	Virginia	Illinois	New York	Montana	New Mexico	Wisconsin	Maryland	Delaware	Nebraska	Italy	Iowa	W. Virginia	Summary
Hubbardston	2½-3½ 2½-3½			3-3½				2½-3									3½	2½-3½
Hurlbut	2½-3½ 2½-3½																3½-3½	2½-3½
Hyde King																		3-3½
Isham Sweet	3-3½																	3½-3½
Jacobs Sweet	3½-3½																	2½-3
Jeffers	2½-3																	2½-3
Jonathan	2½-3½ 2½-3½		2½-3½ 2½-3½	2½-3½ 3		2½-3	2½-2½					2½-2½ 3½-3½	2½-2½ 3½-3½	2½-3	2½-3½	2½-3	2½-3	2½-3
Kaighn										2½-3		2½-2½ 3½-3½	2½-3½		2½-3½	2½-3	2½-2½	2½-2½
King David					3												2½-3	2½-3
Kinnard																	2½-2½	2½-2½
Lady	1½-1½																	1½-1½
Lewer																	2½-3½	2½-3½
Maiden Blush	3-3½		3½-3½		2½							3-3½		3-3½			2½-3	3-3½
Mann												2½-3					3½-3½	3½-3½
McIntosh	2½-3½ 2½-3½		2½-3½ 2½	2½-3½ 2½				2½-3½ 2½-3				2½-3	2½-3	2½-3½	2½-3½		2½-3	2½-3
McMahon											3½-3½							3½-3½
Milding	3-3½ 3-3½																3-3½	3-3½
Missouri																	2½-3	2½-3
Mother	2½-2½				2½												2½-3	2½-2½
Nero												3-3½	3½-3½				3½-3½	3½-3½

TABLE I.—(Continued.)
IDEAL SIZES OF EXHIBITION APPLES, DIAMETER GIVEN IN INCHES.

Variety	New England	Maine	Indiana	Ohio	New Jersey	Virginia	Illinois	New York	Montana	New Mexico	Wisconsin	Maryland	Delaware	Nebraska	Idaho	Iowa	W. Virginia	Summary
Nodhead	2½-3	2½-3						2½-3½							2½-3½			2½-3
Northern Spy	3½-3¾	3½-3¾		3½-3¾	3½-3¾											3-3½	3½-3¾	3½-3¾
Northwestern																		3½-3¾
Nyack					3½-3¾													3½-3¾
Oldenburg	2½-3½	2½-3½			2½									2½-3½			2½-3½	2½-3½
Oliver																		3-3½
Opalescent	3½-3¾	3½-3¾																3½-3¾
Ortley															3½-3¾			3½-3¾
Oxford Black	2½-3	2½-3																2½-3
Palmer	3-3½																	3-3½
Palouse															2½-3½			2½-3½
Patten																		3½-3¾
Peck	2½-3½										3½-3½							2½-3½
Pewaukee	3-3½																3	3-3½
Porter	2½-3½	2½-3½																2½-3½
Pumpkin Sweet	3½-3¾																	3½-3¾
Rainier																		3½-3¾
Ralls				2½-3½								2½-3		2½-3½				2½-3½
Rambo				3-3½								2½						2½-3
Red Astrachan	2½-3½	2½-3½			2½									2½-3			2½-3½	2½-3½

TABLE I—(Continued)
IDEAL SIZES OF EXHIBITION APPLES, DIAMETER GIVEN IN INCHES.

Variety	New England	Maine	Indiana	Ohio	New Jersey	Virginia	Illinois	New York	Montana	New Mexico	Wisconsin	Maryland	Delaware	Nebraska	Idaho	Iowa	W. Virginia	Summary
Tolman	2½-3½	2½-3½		3½-3¾	3½-3¾	2½-3½		3½-3¾				3			2½-3½		3½	2½-3½
Tompkins King	3½-3¾	3½-3¾						3½-4½				3-3½					3½-3¾	3½-3¾
Twenty Ounce	3½-3¾																	3½-4
Virginia Beauty				3½-3¾		2½-3½											3½-3¾	2½-3½
Wagener	3-3½	3-3½							2½-3						2½-3½		3½-3¾	3-3¾
Walbridge	2½-3																	2½-3
Wealthy	2½-3½	2½-3½		3½-3¾	2½	2½-3		2-2½	2½-3		3-3½	2½-3		2½-3		2½-3½	2½-3½	2½-3½
Westfield	2½-3	2½-3													2½-3½			2½-3
White Pearmain																		2½-3½
White Pippin			3-3½	3½-3¾														3-3½
Williams	2½-2¾				2½-3													2½-2¾
Willow							2½-2¾											2½-3
Winesap				2½-3¾	3	2½-2¾	2½-2¾			2½-3		2½-3	3-3½	2½-3	2½-3½	2½-2¾	2½-3	2½-3
Winter Banana	3-3½	3-3½	3½-3¾	3-3¾	3-3¾	2½-3½						3		3½-3¾			3½-3¾	3½-3¾
Winter Paradise				3-3¾		2½-3½											2½-3½	3-3½
Wolf River	3½-4	3½-4		3½-4½							3½-3¾	3½-3¾					3½-4	3½-4
Yellow Bellflower	3-3½	3-3½		3-3¾	2½-3							3					3-3½	3-3½
Yellow Newtown	2½-3½	2½-3½				2½-3½						3-3½					2½-3½	2½-3½
Yellow Transparent	2½-3	2½-3									2½-2¾			2½-3			2½-2¾	2½-3
York Imperial			3½-3¾	3½-3¾		2½-3½					3	3	3½-3¾	3-3½		2½-3½	3½-3¾	3½-3¾
York Stripe												3-3¾						3-3¾

The data collected from growers and dealers varied widely and is probably not of great value, as it is felt that in some cases they did not understand the matter clearly and merely indicated what would constitute a standard commercial pack. It is interesting to note that in nearly every case the professional horticulturists gave larger sizes than the growers or dealers. Table No. 2 gives a summary of the data secured from all three sources for fifteen standard varieties.

TABLE 2.

ESTIMATE OF SIZES OF FIFTEEN VARIETIES BY GROWERS, DEALERS
AND PROFESSIONAL HORTICULTURISTS.

<i>Variety</i>	<i>Dealers</i>	<i>Growers</i>	<i>Horticulturists</i>
Baldwin	2¾ — 3	2¾ — 3¼	3 — 3¾
Rhode Island Greening.....	2¾ — 3¼	3 — 3½	3 — 3¾
Tompkins King.	3 — 3½	3 — 3½	3¼ — 3½
McIntosh	2¾ — 3½	2¾ — 3½	2¾ — 3½
Grimes	2½ — 3¼	2¾ — 3	2¾ — 3
York Imperial.....	2¾ — 3¼	2¾ — 3½	3¼ — 3¾
Esopus	2¾ — 3¼	3 — 3½	3 — 3¾
Stayman Winesap.....	2¾ — 3¼	3 — 3½	3 — 3¾
Winesap	2½ — 3¼	2¾ — 3¼	2¾ — 3
Rome Beauty	3¼ — 3½	3 — 3½	3¼ — 3½
Arkansas	2¾ — 3½	2¾ — 3½	3 — 3½
Jonathan	2½ — 3¼	2½ — 3	2¾ — 3
Gano	2¾ — 3½	3 — 3¼	3 — 3¼
Wealthy	2¾ — 3¼	2¾ — 3¼	2¾ — 3¼
Ben Davis	2¾ — 3½	3 — 3¼	3 — 3¼

Prof. Macoun in his report covering the Dominion of Canada has seen fit to divide the region into four districts with separate recommendations for varieties. The following is his recommendation for the several districts:

SUGGESTED IDEAL SIZE OF APPLES FOR EXHIBITION.

FOR ONTARIO, ALONG LAKE ONTARIO AND DISTRICTS WEST AND SOUTH.

<i>Variety</i>	<i>Inches Diameter</i>	<i>Variety</i>	<i>Inches Diameter</i>	<i>Variety</i>	<i>Inches Diameter</i>
Alexander	4	Mann	2¾	Stark	3
Baldwin	2¾	McIntosh	2¾	Tolman	2½
Ben Davis.....	2¾	Northern Spy.....	3¼	Tompkins King.....	3¼
Blenheim	3¼	Oldenburg	3	Wagener	2¾
Fallawater	3½	Ontario	3½	Wealthy	2¾
Fameuse	2½	Red Astrachan.....	2¾	Wolf River.....	4
Golden Russet	2½	Ribston	2¾	Yellow Transparent.	2¾
Gravenstein	2¾	Rhode Island			
Hubbardston	2¾	Greening	3		

EASTERN ONTARIO, QUEBEC, NEW BRUNSWICK, NORTHERN NOVA SCOTIA,
PRINCE EDWARD ISLAND.

<i>Variety</i>	<i>Inches Diameter</i>	<i>Variety</i>	<i>Inches Diameter</i>	<i>Variety</i>	<i>Inches Diameter</i>
Alexander	4	McIntosh	2¾	Scott Winter.....	2½
Baxter	3½	Milwaukee	3	St. Lawrence.....	3
Bethel	2¾	New Brunswick.....	3	Wolf River.....	4
Ben Davis.....	2¾	Oldenburg	3	Wealthy	2¾
Canada Baldwin....	2½	Pewaukee	3	Yellow Bellflower... 3	
Crimson Beauty....	2¾	Red Astrachan.....	2½	(Bishop Pippin)	
Dudley	3	Scarlet Pippin.....	2¾	Yellow Transparent. 2½	
Fameuse	2½				

FOR NOVA SCOTIA, ANNAPOLIS AND ADJACENT VALLEYS.

<i>Variety</i>	<i>Inches Diameter</i>	<i>Variety</i>	<i>Inches Diameter</i>	<i>Variety</i>	<i>Inches Diameter</i>
Alexander	4	Hubbardston	3	Ribston	3
Baldwin	3	Mann	3	Stark	3
Ben Davis.....	2¾	Northern Spy.....	3¼	Tolman	2¾
Blenheim	3½	Oldenburg	3	Tompkins King....	3½
Cox Orange Pippin..	2½	Ontario	3½	Wagener	2¾
Crimson Beauty....	2¾	R. I. Greening.....	3¼	Wellington	3
Fallawater	3¾	Roxbury Russet ...	3¼	Wealthy	3
Gravenstein	3	(Nonpareil)		Yellow Bellflower... 3	
Golden Russet.....	2¾	Red Astrachan.....	3	(Bishop Pippin)	
(American)					

FOR BRITISH COLUMBIA.

<i>Variety</i>	<i>Inches Diameter</i>	<i>Variety</i>	<i>Inches Diameter</i>	<i>Variety</i>	<i>Inches Diameter</i>
Cox Orange Pippin..	3	King David.....	3½	Wagener	3½
Oldenburg	3	McIntosh	3½	Wealthy	3½
Esopus	3½	Northern Spy.....	3½	Winesap	3
Gravenstein	3½	Rome Beauty.....	3	Winter Banana....	3½
Grimes	3½	Red Astrachan.....	3½	Yellow Transparent. 3	
Jonathan	3	Tompkins King.....	3½	Yellow Newtown....	3

In conclusion your committee wish to state that in their opinion there is but one standard for judging fruit and that is the commercial standard. Any other standard is purely fictitious and without justification. In the preparation of this report your committee have been guided by this thought and in each case to the best of our ability we have tried to indicate the most acceptable commercial size as the one best suited for exhibition purposes.

(It was moved and carried that the score cards presented by the committee at the 1913 meeting be adopted as the official score cards of the Society. These score cards are printed in the 1913 report.)

THE VARIABILITY IN THE LENGTH OF APPLE STEMS.

BY S. H. HOLLISTER,

Connecticut Agricultural College, Storrs, Conn.

Probably every one who has had anything to do with the handling of apples has noticed the great variability in the length and size of the apple stems. This is true not only for the different varieties, but also for the same variety, whether picked from the same tree or from widely separated trees growing in the same orchard or from orchards far apart. These are points which are especially noticeable while one is thinning or harvesting a crop of apples, or while selecting fruit for an exhibit. It has often happened that the writer started in to select a plate of short stem Baldwins and it seemed as though all the perfect specimens were those with long stems. If he changed to a selection of long stemmed fruits then the short stemmed ones seemed to be more in evidence. It is not uncommon to hear growers speak of certain trees producing long stemmed fruit and other trees of the same variety in the orchard producing short stemmed fruit. Recently a large apple grower made the remark that the type of Baldwin stem had changed since he was a boy from being very short and thick and often lipped, to being longer and more slender. Perhaps we wish to settle this point by consulting any standard work on Pomology and we find the character of stem to be "short to medium, often lipped, sometimes long and slender." Thus we are no nearer the solution than we were before.

This question of what is a typical stem for a variety is quite important, especially for the grower who is selecting fruit for an exhibit. Shall he select the long or the short stem? Perhaps the judge may consider the long stem the true type and will give the award to a plate of that type.

Another point which the writer noticed was the shape of the individual fruits with long or short stems. The longer stemmed fruits seemed to be more oblate than the short stemmed ones which were more conical.

With these two points in mind the writer started some experiments two years ago, but owing to his absence when the fruit was harvested the crop was all mixed together.

There are several factors which stand out in this question of stem variability; they are, *first*, do certain trees produce fruit with only one type of stem; *second*, will the tree continue to produce this type of stem year after year; *third*, can it be made to change this type and produce a short stem in place of the long one heretofore produced; *fourth*, are long stemmed apples more desirable than short stemmed ones; *fifth*, does the length of the stem and the shape of the fruit bear any relationship to each other; *sixth*, does the position of the fruit in the flower cluster bear any relationship to the length of stem?

In this short preliminary paper the speaker has considered only the last two factors and particularly the last one, namely, does the position of the fruit in the flower cluster bear any relationship to the length of the stem. His results indicate that there is a direct relationship existing between these two points. To show this we must first consider the inflorescence of the apple which is cymose and centrifugal, that is, the central bud opens first. If this central bud develops into a fruit it will have a much shorter and thicker stem than any of the other flower buds in the same cluster.

A series of measurements of Baldwin stems showed the average length of the center ones in the clusters to be a trifle more than $\frac{1}{8}$ of an inch as compared with a little more than $\frac{1}{4}$ of an inch for the longest stemmed ones. In the fruit clusters where the central flower failed to set the average length of the shortest stems was nearly $\frac{1}{4}$ of an inch, being more than $\frac{1}{4}$ of an inch longer than the shortest stems in clusters with central fruits. With Ben Davis stems the variation in length due to position in the cluster is just a little greater than it is with Baldwin stems.

The general conclusion is that the average length of all the stems in a cluster is less when the central flower has developed, the difference being $\frac{1}{8}$ of an inch when there are only two fruits in a cluster and a gradual lessening of this difference with an increasing number of fruits in the cluster.

Voucher		TREASURER'S REPORT FOR 1914	
No.	1913	Dr.	
	Dec. 8.	To Stamps.....	\$ 2.00
	1914		
1	Jan. 10.	To Badges for 1913 meeting (\$5.00), placards for 1913 meeting (\$1.50), and stereoptican operator for meeting (\$4 13).....	10.63
2.	Jan. 17.	" Rufus H. Darby Printing Co., 2000 letterheads and 1800 envelopes.....	12.75
	Jan. 19.	" Stamps	2.00
	Feb. 10.	" Stamps	2.09
3.	Feb. 28.	" Express on manuscript to printer in Baltimore .	.23
4.	Mar. 17.	" W. W. Green, for reporting 1913 meeting.....	35.00
	Mar. 18.	" Telephone to Thomas & Evans Printing Co., Baltimore	.49
	Apr. 3.	" Stamps	2.00
5.	Apr. 25.	" Express on 1913 reports from Baltimore.....	.80
	Apr. 27.	" Stamps for 1913 reports.....	12.37
6.	May 7.	" Express on 28 reports from Baltimore.....	.35
	June 6.	" Stamps	1.00
7.	July 6.	" Thomas & Evans Prtg. Co., 275 reports for 1913, 165 pages, at \$1.39 per page.....	229.35
	July 8.	" Stamps	1.00
	Aug. 6.	" Stamps	2.00
	Aug. 15.	" Stamps	2.00
	Oct. 19.	" Stamps	1.00
	Oct. 31.	" Letterfile	.25
	Dec. 9.	" Stamps	2.00
8.	Dec. 17.	" Rufus H. Darby Prtg. Co., for 400 programs for 1914 meeting	7.25
			\$326.38

Cr.

1913			
Nov.	20.	By balance on hand.....	\$151.13
	29.	" R. J. Barnett, Pullman, Wash. First 8 reports.....	8.00
Dec.	6.	" Paul Work, Ithaca, N. Y., Report 1913.....	1.00
1914			
Jan.	17.	" Alabama Polytechnic Institute, Reports for 1910, 1911 and 1912.....	3.00
	20.	" Agricultural and Mechanical College of Texas, first 6 reports	6.00
Feb.	20.	" Kentucky Agric. Exp. Station, first 8 reports.....	8.00
Mar.	4.	" Ohio Agric. Exp. Station, report for 1905.....	1.00
	6.	" Thed Pershing, Pineville, Pa., report for 1911.....	1.00
Apr.	10.	" J. W. Firor, Athens, Ga., report for 1911	1.00
May	8.	" University of Arkansas, reports for 1908-9, 1910, 1911 1912, and 1913	5.00
	9.	" G. W. Koiner, Richmond, Va., report for 1913.....	1.00
	14.	" University of Georgia, Athens, Ga., report for 1913...	1.00
	28.	" University of California, first 9 reports.....	9.00
	30.	" Mass. Agric. College, report for 1913.....	1.00
June	2.	" Experiment Station, West Raleigh, N. C., report for 1913	1.00
	10.	" Agricultural and Mechanical College of Texas, report for 1913	1.00
	10.	" Orange Judd Co., 2 reports for 1913	2.00
	17.	" Pennsylvania State College, report for 1913.....	1.00
	17.	" F. M. Clement, Vineland Station, Ontario, first 8 reports	8.00
	23.	" Agricultural College of Colorado, reports for 1912 and 1913	2.00
	25.	" University of Vermont, report for 1913.....	1.00
	29.	" Chas. B. Sayre, Champaign, Ill., reports for 1912 and 1913	2.00
July	2.	" University of Wisconsin, report for 1913.....	1.00
	2.	" Iowa State College, reports for 1910 and 1913.....	2.00
	20.	" University of Maine, report for 1913.....	1.00
	28.	" University of Nebraska, first 9 reports.....	9.00
	31.	" Rutgers' College, first 9 reports.....	9.00
Sept.	2.	" Ohio State University, report for 1913.....	1.00
	22.	" The Baker and Taylor Co., N. Y. City, report for 1912	1.00
	28.	" University of California, first 9 reports.....	9.00
	30.	" Mass. Agricultural College, report for 1913.....	1.00
Oct.	12.	" War Department for Porto Rico Exp. Station, first 9 reports	9.00
	20.	" H. M. Brown, Philadelphia, Pa., report for 1913.....	1.00
	21.	" W. E. Hoyt, New York City, report for 1913.....	1.00
Nov.	17.	" Geo. F. Potter, Madison, Wis., report for 1913.....	1.00
	18.	" R. B. Vandergrift, Phila., Pa., report for 1913.....	1.00
	21.	" Richard A. Metcalf, N. Y. City, report for 1913.....	1.00
	23.	" Southern Oregon Exp. Station, report for 1913.....	1.00
	28.	" F. M. Clement, Vineland Station, Ontario, report for 1913	1.00
Dec.	1.	" State College of Washington, first 9 reports.....	9.00
	3.	" Agricultural College of Utah, first 9 reports.....	9.00
	26.	" William Stuart, U. S. Dep't. Agr., report for 1907....	1.00
		" Dues paid during the year.....	180.00

\$464.13

Balance on hand\$137.75

Respectfully submitted,

C. P. CLOSE, Treasurer.

The Auditing Committee reported that it had examined the accounts of the Treasurer and found them to be correct.

H. J. EUSTACE,
C. A. McCUE,
T. C. JOHNSON,
Committee.

(After the Treasurer's report had been adopted a motion was passed authorizing the Society to pay the expenses of the Secretary in attending the meeting.)

WEDNESDAY, DECEMBER 30, 9:30 A. M.

PRESIDENT CORBETT: The papers presented at yesterday's sessions and the discussion following were, I am sure, a pleasure and stimulus to every one present. The part of the program yet remaining promises as many good things as we have already enjoyed. The list is a long one and will require all the time at our disposal and unless there is objection the plan of yesterday will be followed and discussion postponed until the papers of the morning have been heard.

SOME PROBLEMS CONNECTED WITH KILLING BY LOW TEMPERATURE.

By W. H. CHANDLER,

Cornell University, Ithaca, N. Y.

It is not necessary to emphasize the importance of winter and spring freezes in the fruit industry, and few problems relating to fruit-growing have been the subject of more extended study. While the pomologist's interest is directly in the means of obviating injuries by low temperature, yet a study of the cause, or nature of such injury, may also be of interest to him, since such knowledge would seem to be essential to any intelligent study concerning means of obviating injury.

In a discussion of this subject it is necessary to specify just what phenomena are being discussed since there are apparently a number of phenomena commonly classed under winter injury, such as death by evaporation from twigs and leaves when the soil or the tree trunk is frozen so that the moisture supply is shut off, or when the soil temperature is so low that in case of some plants no water is taken up. The phenomenon discussed here is that observed at once on thawing when the tissue is submitted to killing temperature. There is a brown and watery appearance, and evaporation, at least from succulent tissues, is much more rapid than before it was frozen to death. Under the microscope a movement of the coloring matter from colored cells to the intercellular spaces, or to adjacent cells not colored may be observed. In case of all succulent tissues, including winter fruit buds, death may be observed in a very short time by the brown watery appearance after thawing.

The most extended studies concerning this phenomenon of killing by cold have been made in European countries. When it was first learned that ice was to be found in the tissue it was naturally supposed that the ice crystals would be found within the cells. However, Geoppert observed that the formation of the ice is often in the intercellular spaces, and Sachs found that the ice formation under normal rate of temperature fall is nearly always in the intercellular spaces. Perhaps the most valuable contribution to our knowledge of injury to plant tissue from freezing has been made by Müller-Thurgau. He showed that death from freezing does not occur unless ice forms, that is, when tissue was kept super-cooled for varying lengths of time to temperatures even lower than that at which it normally kills, no injury occurred provided the tissue could be warmed to the freezing point without ice formation. He also observed the frozen tissue rather more carefully than it had been observed by others, and found, that on freezing, the water is withdrawn from the cell to form ice crystals in the intercellular spaces. Molisch, by very careful studies, confirmed the results of Müller-Thurgau. Molisch and Müller-Thurgau both came to the conclusion that death to the tissue results from the rapid withdrawal of the water from the cells. In the case of some plants, especially the white orchids, they were able to demonstrate that death may actually occur before the tissue begins to thaw.

Recently Maximow has made a very interesting contribution to our knowledge of frozen tissue. He used small pieces of red cabbage and *tradescantia* leaves. The tissue was frozen in pure water and in solutions of varying strengths of a number of organic and inorganic compounds. He found that wherever the substance used in solution was not extremely toxic and where it stayed in solution at low temperatures, very great protection was offered by the material in solution. An interesting feature of this work was that when the tissue was dropped into the solutions and immediately frozen as much protection was to be observed as where the tissue was kept in the solution long enough for it to enter the cell and increase the sap concentration. Apparently, then, the injury from the withdrawal of water, or whatever causes the injury, under Maximow's conditions at least, was to the plasma membrane only, though some observers had previously held the opinion that the injury would be first to the nucleus.

Keith, working with bacteria, has recently found that materials in solution protect the cells from injury at a given temperature, but more interesting still, that working the ice into a sherbet had the same effect, that is, bacteria in a sherbet ice would not be killed at as high a temperature as that at which they were killed in solid ice.

The speaker was able to increase the hardness of plant tissue by permitting it to absorb various solutions, but the increased hardness was nothing like so great as that observed by Maximow and Keith when the tissue was frozen surrounded by the solutions. However, there is just one possible source of error in Maximow's work. He

froze his checks in pure water and not in air. Tissue with wet surfaces will in nearly all cases kill at a higher temperature than that with dry surfaces, and when the tissue is surrounded by considerable masses of ice and the temperature is as low as if the ice were not there, unquestionably the killing temperature would be somewhat higher. It is doubtful in my opinion, whether in view of the work of Maximow and Keith we can still accept so simple a theory as that of water removal alone as an explanation of the injury from freezing. It should be further considered that those tissues, which will withstand the lowest temperatures, contain very small percentages of moisture. Thus, seeds have been exposed to a temperature of liquid hydrogen for six hours when they were perfectly dry and no injury resulted. The placing of seeds in water for a very few hours will greatly reduce their resistance to low temperature. We may assume that the protoplasm in such tissues as seeds and cambium has reached a condition where its water requirements are very small. Yet it would hardly seem probable that but a few hours' exposure to moist conditions would greatly change the condition of the protoplasm with reference to its water requirements. I may say, further, that in my own experience, buds of peach trees will withstand considerably lower temperatures when they are rather badly wilted. It seems possible that reducing the moisture content actually increases the hardiness, and it would not be surprising if we learned that the water withdrawal is merely associated with death from freezing without being its cause. The immediate cause of death may not be the same in all frozen tissue. According to the work of Gorke and Schaffnit precipitation of proteids is sometimes associated at least with freezing to death of plant tissues if it is not the cause.

Closely related to the cause of death from freezing is the effect of the rate of thawing on the amount of injury. It early seemed to be the common opinion that the rate of thawing determines the amount of injury. Geoppert was of the opinion, however, that the rate of thawing very slightly affects the amount of injury, if it affects it at all. Sachs froze such tender tissues as pumpkin leaves in water and found that tissue frozen in this way did not kill, while if frozen in air so that it thawed more rapidly it would kill. Müller-Thurgau was led to the same conclusion because when he stood stems of plants in water, and let water, stems and all freeze, the tissue on thawing was killed above the water but uninjured beneath it. He later found, however, that the tissue beneath the water had never been frozen, the freezing point of the tissue being lower than that of the water, and the water never having reached as low a temperature as that of the air. Sachs also seemed to find that when he immersed frozen tissue in water it recovered, when if it was thawed in the air it killed. Müller-Thurgau, however, showed both by reference to physical laws and by experimental evidence that if Sachs saved the tissue by immersing it in water, he saved it by means of very rapid thawing rather than by slow thawing. When the tissue is immersed in the cold water immediately, masses

of ice will form on the surface. The eighty units of latent heat are then available to thaw the tissue within. It should further be considered that the specific heat of water is very much greater than that of air. Then, by actual observations Müller-Thurgau learned that in all cases the ice crystals would be out of tissue so thawed in cold water more quickly than it would be out of the tissue kept at room temperature. He studied the effect of slow and rapid thawing on the tissue of some three hundred different plants and came to the conclusion that the rate of thawing has nothing to do with death from cold. Later, however, he found, what is common knowledge to us, that if the temperature does not go too low the rate of thawing very materially affects the amount of injury in case of ripe apples and pears. Molisch also studied the effect of the rate of thawing on between two and three hundred plants, and confirmed the results of Müller-Thurgau. However, he found that slow thawing reduced the injury to the leaves of the century plant also. In our own experience, we have found that slow thawing very slightly reduces the injury at the maximum killing temperature of lettuce leaves. The difference here, however, is nothing like so great as in the case of ripe apples. It should be remarked that by slow thawing of tissue is meant actually slow thawing, and not thawing in cold water which is rapid thawing. Thus, thawing the apple in cold water is apparently as injurious as thawing it rapidly in the air at a high temperature, but if it remains at a low temperature, which rises very gradually, it can be taken to considerably lower temperature without injury than if thawed rapidly. In rather extended studies with blossoms and young fruit at the Missouri Experiment Station we came to the conclusion that the rate of thawing has nothing whatever to do with the killing temperature of such tissues and the interesting fact was observed further in the case of apple fruits two-thirds grown, no benefit whatever could be observed from slow thawing, though marked benefit was observed from the slow thawing of ripe apples and pears. In case of ripe peaches, potatoes and other succulent tissue, as well as in the case of roots, buds, leaves and blossoms, no beneficial result from slow thawing was observed. The statement is often seen in literature that it is the thawing that determines the amount of injury. That is, if thawing is so slow that the water may be taken back into the cell before its evaporation, injury does not result. Such a statement would seem very far out of harmony with the facts. The tissue that is most markedly benefited by the slow thawing (ripe apples and pears) has relatively such a small evaporation surface that even with the killed tissue, water loss is so slow that what is lost before the cells are able to take the water back could not be a determining factor. If such a theory were true the greatest benefit from the effect of slow thawing would be observed with tissue that loses water rapidly, such as leaves, flower petals, etc. It should also be remembered, as Müller-Thurgau points out, that slow thawing will, in the case of a few tissues, reduce the injury from the maximum temperatures that kill, yet

when the tissue is taken to a somewhat lower temperature it kills regardless of the rate of thawing. The rate of thawing, even in these cases is not a determining factor, but only a factor that slightly influences the killing, and it does not seem possible that this influence can be explained by the statement that it enables the cell to take the water back before it is evaporated. I should say here, that according to a letter from Dr. H. J. Weber, it is the experience of orange growers that the greatest injury is to be observed on the southeast side of the tree, the side that is first reached by the morning sun.

This would seem to indicate that the orange represents another tissue that is benefited by slow thawing. Recently in a letter to Dr. L. H. Bailey, O'Gara states that the same phenomenon is observed in the case of other fruits in the Pacific Northwest, and where he has protected pear trees from the morning sun the injury was reduced, or prevented altogether. Yet in my own experience, under controlled conditions, the most rapid thawing compared with the slowest thawing possible did not change the results with young fruits and blossoms. O'Gara further states that where he has sprayed the tree with water in early morning, so that ice collected on the surface of the tissues, he also reduced, or prevented, injury. This last certainly was a means not of slow thawing, but of very rapid thawing, in fact almost instantaneous thawing. Thus, when the sun's rays have been kept off the frozen tissue less injury has resulted, but when the tissue has been thawed at once so that there would be no frozen tissue for the sun's rays to reach, injury has been reduced or prevented. It would seem possible, then, that there might be an injurious effect of the sun's rays on frozen tissue. This certainly offers an interesting field for investigation. The fact that ice gathered on the surface would, of course, be no indication that ice was left within the tissue for the freezing point of the tissue is lower than that of the water on the surface, and the latent heat given off in ice formation, if there were much ice formed on the surface, would make it impossible that any ice could remain within the tissue unless the ice on the surface were below the freezing point.

Of interest in this regard also is the rate of temperature fall. Until recently able physiologists, like Pheffer, were of the opinion that the rate of temperature fall also has little or no influence on the amount of killing. This was probably because most of the study that had been given to the subject was with succulent tissue that kills at a rather high temperature. In the case of winter dormant tissue, however, the rate of temperature fall has a very marked influence on the killing. Thus Winkler, working with Pheffer, found that he could gradually lower the killing temperature of winter twigs by lowering the temperature very slowly; and in our own experience tissue that may withstand temperatures of -40°F. will be killed around 0°F. if the temperature fall is especially rapid. It seems possible that this may offer some explanation of sunscald, providing that injury is learned positively to be a form of winter

injury. The temperature on the sunny side of a tree trunk may be 20 to 30 degrees above air temperature on a clear afternoon. This increased temperature is maintained rather late in the afternoon because as the sun goes down the rays strike the trunk more directly. As soon as the sun is off the trunk, however, the temperature fall is very rapid.

Perhaps the effect of low temperature is more important with peach growing than with any other temperate zone fruit. In case of the winter dormant buds again, the rate of temperature fall seems to be an important factor. When the temperature fall is somewhat rapid, that is, when the killing night is not preceded by a rather long cold period, from all the experience we have been able to gather, we may expect the dormant buds of most varieties of peaches to be killed by temperature around -10° to -12° F. Yet I have known a fair crop of peaches to be borne on some trees following a temperature of -25° F. In all such cases, of which we have found records, there was anywhere from a week to several weeks of weather in which the temperature did not reach the thawing point throughout the period. Thus, the temperature fall would be very gradual and it seems highly probable that this explains the few cases where peach buds withstand such low temperatures. Of course, a few buds on a tree may be in a considerably wilted condition so that they will withstand lower temperatures even when the temperature fall is somewhat rapid. I think, then, we are safe in placing the killing temperature of buds, of nearly all varieties of peaches, at approximately -10° to -12° F., when the temperature drops from the freezing point within one or two days. Thus, in New York during the past season there were practically no peaches left, and yet in the important peach regions the temperatures were not much below -10° F. The minimum temperatures for the year in a few of the important peach sections were as follows:

Rochester	-11°
Brockport	-15°
Lockport	-12°
Geneva	-14°

In most cases the peach sections were in locations slightly more protected than the cities mentioned, yet in all cases practically all the peach buds were killed. At Irondequoit, somewhat nearer Lake Erie than Rochester is, the Elberta and Crawford were practically all killed, although Carman and Greensboro had enough live buds left for a fair crop if conditions had been favorable at blooming time. Local growers reported a temperature of -9° F. to -11° F. It is interesting to note that there are but a few degrees of difference in killing temperature of most of the varieties of peaches, the Hills Chili group, the Stevens Rareripe and some of the Chinese Cling peaches like Carman and Greensboro, are more hardy than the Elberta and Crawford types, yet the difference represents perhaps not more than two or three degrees when the temperature fall is

normally rapid. It is often stated that the loss of water from the peach buds raises the killing temperature, yet as I have previously stated, we girdled peach limbs in winter cutting through the sap wood so that the moisture content was appreciably reduced, they went through a temperature that killed the other buds on the same trees, or on different trees in the same orchard. It has further been our experience that when we have killed the buds artificially under conditions where evaporation could play no part, they have killed at just as high a temperature as when they killed naturally, and at higher temperature if the fall was more rapid. It may also be of interest to note that when we have removed the scales from peach buds before freezing them, a smaller percentage would be killed at the same temperature and under the same conditions than when the scales were not removed.

It is probably true that many phenomena associated with killing at a low temperature are nothing more than the effects of evaporation during a period when the source of water to the tissue is cut off because of its frozen condition. Thus, red raspberries seem entirely hardy in Alaska, and yet often kill in Missouri and nearly always in Nebraska. Professor R. A. Emerson has shown that death results solely from their drying out in winter. Thus, when he merely coated the canes with paraffin they survived the winter, while practically no untreated canes came through alive. The twigs of fruit trees are likely to be killed in such regions as the Dakotas, and may possibly under certain conditions be killed further south and east. It is doubtful if this is often associated with phenomena to be observed in the tissue as killing resulting directly from low temperature. Yet Shutt and Allen each seemed to find a marked correlation between the moisture content or rate of water loss from apple twigs and the hardiness of given varieties. The most important factor that influences the hardiness of winter tissues is maturity. In the case of the cambium, if not in the case of some other tissue, this maturity is associated with a reduction in the moisture content as well as a thickening of the cell walls, hence, it would seem that high moisture content or rapid water loss would indicate a less advanced condition of maturity. In that case it would seem probable that the tissue with a high moisture content is tender because the water is there and not because it is lost. Reduced water content, however, would not fully explain the very gradually increased hardiness of some winter tissue. There is no great reduction in the moisture content of cortex during winter, and yet it may be killed at a temperature of a few degrees below freezing in summer and may withstand as much as 80° F. below freezing in winter. It seems hardly probable that the increased concentration of the sap explains this since the cortex is much more hardy in January than at the time of leaf fall, and yet there is very little difference in the sap concentration as measured by the freezing point. It would seem probable that in a state of maturity besides the reduced water supply the protoplasm simply acquires a condition that enables it to withstand a larger amount of ice formation with the resulting

removal of water from the plasma membrane or whatever else causes injury to the cell protoplasm on freezing.

In case of peach fruit buds, keeping them mature through warm periods of winter is of as great importance as having them reach a normal condition of maturity in autumn. The writer found in experiments in South Missouri that prolonging the rest period in winter by keeping the tree in a vigorous condition may serve to keep the buds dormant later and increase the probability of their surviving the winter.

At Brandsville, Missouri, plots of peach trees were pruned severely and plots were fertilized heavily with nitrates. In each case the season's growth was very vigorous. On February 22, 1910, the untreated trees were nearly in full bloom, and the crop was destroyed by a temperature of 14°F. The buds on the pruned and fertilized trees were not as far along by March 16 when another freeze came. These trees bore practically a full crop while untreated trees bore nothing.

On no other years have the results of such treatment been so marked, but on nearly every year there was some difference, the buds starting more slowly on the vigorous trees. This is not true in the North because there are no warm days to push the buds before the rest period is ended.

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PRESIDENT'S ADDRESS.**HORTICULTURAL INVESTIGATIONS—A RETROSPECT**

By L. C. CORBETT,

U. S. Department of Agriculture, Washington, D. C.

In no other scientific activity has the individual found greater opportunity to express his point of view and the influence of his early training than in the field of horticultural research. The early training of an individual has a marked bearing upon his activities in later life. If, immediately upon completing his course of study, a young man is thrown upon his own resources in a comparatively new field, his work is very apt to reflect the influence of the instruction he has received.

In the early days, those engaged in horticultural work were largely men fresh from the institutions and strange to the environments in which they found themselves. As a result, because of the necessity of turning out a product, many simple activities of a theoretical nature were selected and conducted, either in greenhouses or field plots, from a laboratory standpoint. In nature these investigations were, for the most part, unrelated to the horticultural problems of the states in which they were conducted. True it is that the industries were not as extensive or as highly specialized as they are today, but, nevertheless, specific problems existed in quite as great profusion and were quite as important to the industry as those presented for solution today. The fact that limited funds were at the disposal of the investigator made it impossible for him to familiarize himself with the horticultural activities of the state. His problems, if they were problems of the state, were often suggested through correspondence or were contributions of his own mind and chosen largely from preference or because a similar line of work had interested him during his college career. I cite this for the reason that an inventory of the horticultural activities of the various states, as portrayed in their publications, clearly shows that a large part of the energy and funds which have been devoted to horticultural activities have been directed to minor rather than to major problems.

An analysis of the work carried on by the state experiment stations and the Federal Department of Agriculture along horticultural lines demonstrates the truth of these assertions. Notwithstanding the diversity of the field covered and the various personal attributes possessed by those engaged in the work, it is possible to segregate it into general classes or types of investigation. Those which I believe all will agree to are:

1. Theoretical considerations.
2. Systematic studies of horticultural groups.
3. Variety tests.
4. Descriptive expositions (covering crop growing, regional distribution and crop adaptations).
5. Surveys of a statistical or economic nature.
6. Special industrial problems.

I. THEORETICAL INVESTIGATIONS.

These investigations, for the most part, have been directed toward the solution of specific problems which have an indirect or remote bearing upon the industry. The object of these investigations has been to gather information of a general nature rather than to find the solution of specific problems directly connected with an enterprise. In the early days of investigational work in horticulture, this type of problem was more common than at present. While no considerable portion of the energy or funds devoted to experimental work in horticulture has been devoted to such activities, yet investigations of the influence of incandescence gas light on plant growth, or the effect of an electric current on the growth and behavior of seedlings, may be taken as the type of work which is in mind. And I believe that when the light of history is turned upon the so-called plant breeding work now under way much of it will be classified under this caption. A study of the manifestations of hypothetical pairs under immeasurable stimuli comes well within the limits of theoretical investigation.

II. SYSTEMATIC STUDIES OF HORTICULTURAL GROUPS.

This type of investigation, as a review of the horticultural literature will demonstrate, was a favorite among many of the early workers in horticulture and I am glad to say that it has not entirely gone out of fashion even up to the present time. This line of endeavor was undoubtedly suggested from two points. One of the influences directing attention to it was the early training of the men pursuing horticultural research. Many of those to whom horticultural investigations were intrusted were fresh from the class rooms and laboratories of leading teachers of systematic botany. Their training in systematic work led them immediately to observe the shortcomings of horticultural literature in that it lacked systematic handling of horticultural groups.

A second consideration influencing those possessing a knowledge of systematic principles to undertake the work of unraveling some of the horticultural tangles was that systematists in general had assiduously left cultivated plants alone and had considered them unworthy of attention. The change of attitude towards the study of cultivated plants which has come about in the last quarter-century requires no discussion before this society further than to say that the conception of botany has been more profoundly modified within the last 25 years than that of any other science.

The work of Sturtevant, of Bailey, of Hume, and of Waugh, will serve to illustrate sufficiently the type of work falling under this classification. Such work is definite, clear-cut and constructive, but it has greater interest for students and teachers than for practical horticulturists. It increases the efficiency of the investigator without enhancing the value of an industry.

III. VARIETY TESTS.

Another activity which has engaged the attention of horticultural students from the founding of the experiment stations to the present time, has been that of variety testing. Variety tests have been conducted with every conceivable class of fruit and vegetable. I do not think it is an exaggeration to say that fully one-fourth of the horticultural publications which have emanated from the state experiment stations, bear evidence of this type of work, sometimes under the name of variety tests and sometimes under a *nom de plume* such as adaptation studies, fertilizer tests, etc., which in large measure are of the same general character, and lead to the same general unsatisfactory result. I believe I am safe in saying that every horticulturist in this audience has at one time or another deplored the fact that so much time and attention have been given to variety tests which were not comparable with any other work done by any one else in any other state, yet every one of us has been guilty of contributing to this hodge-podge and still the game goes merrily on.

I suspect I have said as much as any other horticulturist on the subject of variety testing, but, as you all know, I have endeavored to direct the energy which the stations seem *bound* to put into this activity, along lines which would make the results comparable and to an extent worth while. Just how far this idea has taken hold of those who are engaged in variety test work I will leave for you to decide.

Variety testing has been with us from the beginning, it will probably continue with us to the end. I hope that, as time progresses, the work will take on some aspects which will make it really worth while. If it did no more than point out the comparative adaptability of varieties to different soils and climatic conditions in such a way that the results could be used, in later years, by students of plant variation for the purpose of determining the evolutionary trend of our leading horticultural plants, it would be justified. If the records were carefully made and systematically recorded upon a comparable basis such far-reaching results might be expected, but under the "*laissez faire*" system which has been chiefly in vogue up to the present time no such result can be hoped for.

IV. DESCRIPTIVE EXPOSITIONS.

The next definite period in the evolution of horticultural literature was the description of the activities and industries which had grown up. This was undertaken as soon as horticulturists were provided with sufficient funds and allowed time to study the enterprises of the states in which they were located. This came about as a result of the additions made to the Hatch fund and the divorcing of the instructional and investigational work in the institutions. It became evident that there was a great dearth of information regarding the extent and importance of the various horticultural activities. **A need for a series of bulletins describing the practices of successful**

commercial horticulturists seemed to exist. This was particularly true of vegetable culture as the work done by the experiment stations had been largely variety testing. The methods followed by the successful cultivators of crops under glass as well as those engaged in successful truck farming, had not been described in the popular press or to any considerable extent by the writers of books. In order to make these practices and the information possessed by those engaged in such industries available, descriptive bulletins were necessary. The same methods have also been followed in describing the fruit interests.

In some instances an attempt was made not only to describe an industry as it existed in a certain locality, but also to point out other suitable areas which might be devoted to the same activity. In other words, these publications not only described the industries, but actually gave an impetus to their extension by pointing out areas in which the work might be undertaken. Some of the important results which have followed this effort are: A more intimate knowledge of the industries; information regarding the regions in which they might be extended and the problems which were likely to be encountered in their extension and development; and, most important of all, that intimate touch with the industries which is so important to the successful solution of specific problems. In fact, they made the investigator more a part of his investigation and the investigations themselves came to be a direct outgrowth of the needs of the industries.

V. SURVEYS OF A STATISTICAL OR ECONOMIC NATURE.

About this time it became evident that *a solution of the problems of production* was not in itself the key to all the difficulties incident to a large and rapidly-developing industry. Improved transportation facilities which brought about the substitution of fast freight for express shipment; the invention of the refrigerator car, which further extended the zone of perishable freight traffic; the application of refrigeration to perishable products by which their market period was extended; and finally, the congestion of these products in large centers to which the transportation systems of the country led, developed problems of a far-reaching character which were vital to the ultimate well-being of the industries which they touched.

It further became evident that the field of horticultural research must be extended to take into consideration not only the problems of production, but also the economic problems entering into handling, transportation, storage, and distribution of horticultural products. A fundamental step in this direction was taken by inaugurating surveys of the industries to determine the reasons why a certain crop gives satisfactory returns in one locality and fails to give satisfactory returns in another; to determine the relative cost factors entering into the production of various crops in the several localities in which their cultivation had developed; and further to determine the relation which transportation, handling, and storage bear to the life and distribution of the product. The early work in this field

such as that carried on by the horticultural division of Cornell University in its orchard surveys, while given a purely pomological setting, nevertheless took into consideration many of the economic factors entering into the cost of production.

Up to this time, as has been stated, the work in horticulture as well as in agronomy had been chiefly directed to stimulating production and extending the areas under cultivation. It has been found, however, that all agricultural industries tend to follow the laws of liquids and come to a dead level or position of stability brought about by the selling price tending at all times to approach the cost of production. To explain this law more in detail, it has been observed that industries are rapidly extended or intensified so long as there is a margin of profit. As soon as the selling price falls below the cost of production there is a marked falling off in the production of the commodity. This law holds in horticulture as well as in all other business activities. The economic surveys which have been conducted from a horticultural standpoint, have been carried on for the purpose of determining for each locality the limiting factors of the industry. The results revealed by these statistical and economic studies led to the development of more economical and satisfactory methods of marketing which have found expression in such organizations as the California Citrus Exchange, North Pacific Fruit Distributors, the Eastern Shore of Virginia Produce Exchange, and other well-organized marketing associations. These agencies, as soon as they undertook the work of marketing, immediately found that their greatest problem lay in the field of distribution. Methods of handling had to be devised which would insure the safe delivery of products from distant fields of production over a widely scattered market area and thus prevent the congestion of perishable products in a few terminal points to an extent that might cause loss. The final outcome of this has been the establishment in the Department of Agriculture of activities for the purpose of studying the handling, distribution and marketing of various agricultural crops, including fruits and vegetables.

VI. SPECIAL INDUSTRIAL PROBLEMS.

The development of highly specialized features for the purpose of extending and making the various horticultural industries more *profitable* and more *stable* has naturally brought into existence a new group of *special industrial problems*. A consideration of the methods of attacking these problems forms the final topic of our discourse.

In order to satisfactorily solve the problems of an industry it is necessary to study the industry as a unit. In many of the institutions there has existed a type of organization which has been more or less loose and individual in character. This type of organization does not permit either of investigating an industry or of solving the more complex problems of an industry. In other institutions a point of view has developed which is that of investigating *special problems*. In these, the work and projects of the various scientists pur-

suing specialties bearing upon any problem, have been so grouped and correlated as to direct them simultaneously upon an industry or the problems of an industry. This method of attacking special problems has developed a spirit of team work between horticulturists and entomologists, between horticulturists and pathologists, and between horticulturists and chemists. It is this type of investigational activity which, when properly organized and stimulated by wise administration, contributes most to the success of the industry and it is, after all, the benefit to the industry as a whole that the investigators in all branches of work are striving for. The splendid team work carried on by Mr. Scott and Mr. Quaintance in the United States Department of Agriculture will serve as an illustration of this type of effective cooperation.

The state colleges and experiment stations, with their Adams funds, are in a position to attack industrial problems through the method I have just mentioned. By outlining a cooperative project covering the various phases of the industry needing investigating and assigning these to the different scientists fitted to attack them, it is possible for the states to develop a line of research which will have a more effective bearing than has been possible under the previously existing plan of attack.

In general it is desirable to pursue investigational work from the standpoint of *the industry* rather than from the standpoint of *special problems*, but in order to develop specialists of high attainment along certain lines it is essential that there be a group of projects based on problems which absolutely cross-cut the industrial activities. By that I mean that it is undoubtedly better in a large institution where there are a number of lines of work, each of which involves the same general principles of utilization, to develop the utilization point of view in some one investigator or group of investigators rather than to attempt to make each crop man proficient in the utilization of the products with which he is dealing. As an illustration, I may cite the question of canning and preserving. If, in developing the fruit interests of a state, which may cover strawberries, apples, peaches and plums, as is the case in many of our eastern states, it might be more advantageous to develop a laboratory manned by specialists who could devote their entire time and attention to dessication, canning, preserving, and pickling, rather than to attempt to have each fruit specialist who is concerned primarily with the cultivation, harvesting, and packing of these products for the market, handle the drying, canning and preserving problems for his crop. I realize, however, that this is primarily an administrative problem, but it does have an important bearing upon the peace of mind of the investigators concerned. If this type of cross-cut project is undertaken the two groups of men handling the production and the utilization phases must be temperamentally fitted to do team work, otherwise the projects are bound to suffer.

CONCLUSION.

While this plan of handling research work in horticulture possesses some factors which are difficult to adjust, it also possesses

many advantages. One of the results which might be mentioned is that the previous condition of servitude of young men just out of college modifies such research work to a very much less extent than was the case a few years ago when they found themselves in charge of the horticultural problems of a state with which they were horticulturally not familiar. Young men called to take part in constructive work nowadays usually enter the field to take up some particular phase of a project which has been carefully outlined and developed by older and more experienced individuals to a point where it is desirable to have additional assistance. Under these conditions projects become more stable and they are prosecuted more intensively.

Another encouraging feature of our work is that the institutions are growing to appreciate the importance of uninterrupted work which tends to make the personnel of the stations more stable and enables the investigators to undertake and carry out difficult, long-time projects. The projects themselves are based upon the industries, are practical rather than theoretical, and deal with major rather than minor problems.

If there was no increased stability to the projects and no improvement in the character of the investigations, our horticultural fraternity would have little cause for congratulation. The growth of commercial horticulture, and the faith which those engaged in commercial horticulture repose in investigational work are, it seems to me, an expression of approval, but all this, gratifying as it is, imposes upon us the responsibility of wisely administering an increased trust.

GRADUATE WORK IN HORTICULTURE.

BY M. J. DORSEY, *University of Minnesota, St. Paul, Minnesota.*

The demand for practical instruction has been quite general in a number of fields of applied science in the last two decades or so. This demand for instruction in subjects more closely related with the life of the individual has been so extensive that it has become a topic of serious consideration in educational circles. In many instances the older classics as subjects of educational training are being almost wholly replaced. While this change has been quite general over the country, there seems to be no indication of a turn, at least immediately, and careful consideration should be given to the general movement in its relation to the more or less specialized fields.

The general status and evolution of horticulture, along with other subjects, has its setting in this movement and it may be opportune at this time to discuss briefly the relation between the present status of horticulture and graduate work or advanced training which will so intimately influence future development.

General Relations. Undergraduate instruction has been given considerable attention by this Society in its relation to practice and the underlying sciences. Further discussion of either undergrad-

uate or graduate work introduces the general question of the relation of our present organization and viewpoint to the direction or emphasis of our efforts in the future.

To begin with we shall look upon horticulture as a composite term, including, in most institutions, pomology, olericulture, floriculture, landscape gardening, etc. It is still capable of further division and specialization. As our agricultural institutions are organized at present, most departments of horticulture are called upon to serve in three fields—speaking now from the standpoint of the division of activities resulting from the present organization—namely, extension, teaching and research. This division of the general subject from the standpoint of administration or subject matter has been an evolutionary development and seems liable to persist for some time to come.

In common with other divisions of agriculture, horticulture has expanded, thrown off some satellites and has itself become divided and specialized. With this development the problems confronting horticulture have at the same time become more specific and also more general—more specific in that research has suggested and led to different phases of every problem, and more general in that the present economic tendency toward centralization and standardization has also had its influence, in this field.

Since the broadening field has led to a different grouping from the organizational standpoint, it follows that specialization in some particular phase of the work by the would-be investigator or teacher is optional, but at the same time necessary. It follows, also, that, since the most rapid advancement is made by trained men, the opportunity for graduate work must of necessity be developed in all lines, preferably equally. This confronts our departments of horticulture with some interesting problems, both from the standpoint of the development of a graduate viewpoint and spirit, as well as from the standpoint of organization.

This introduces the question of institutional, as well as individual responsibility, which carries with it the query as to whether all institutions shall attempt to develop well balanced departments in all branches of the subject with the consequent expensive equipment as well as expensive personnel. Here it is evident that the discussion overlaps the field of organization and administration, but, even if our ambitions reach out to this extent ultimately, it will be clear to most members of the Society, scattered as we are, that the present lines of development are closely allied with service and support or demand, which in turn result largely from the diversification of the industry.

While it is probably not possible, then, or perhaps at present not even desirable, for a parallel uniform development of horticulture in the various institutions to take place; it is possible and desirable to recognize and adopt, as far as our efforts go toward giving instruction and training, some well formed standards and ideals as to what shall constitute graduate work and also the methods employed in giving it.

The Viewpoint. Knowing something of the work yet confronting research, teaching and practice, our object in offering graduate training and instruction shall be to turn out men with a type of training which will enable them to undertake the solution of these problems intelligently. It is generally recognized that horticulture is an art and that research in this field is largely the application of science. This should be given even more recognition and emphasis in the future than in the past, for upon such recognition much of our teaching practice receives direction and from it we get a clearer idea of the two main efforts of our instruction and training, namely, (a) familiarity with the materials and (b) familiarity with the underlying sciences. It is here that a provisional distinction can be made between undergraduate and graduate work. Our departmental efforts in undergraduate instruction are chiefly directed toward giving the student a knowledge of horticultural materials and methods, leaving it to other departments, such as botany, chemistry, physics, etc., to fill in with the underlying sciences. What shall our attitude be toward the graduate work? Shall it be mainly requiring further familiarization with the same or other materials, or something else? This question is fundamental and no doubt will be answered in many different ways, according to the viewpoint which is gained by experience and training.

It will be advisable before giving the answer to recognize, or at least to state, other considerations. (1) The object of graduate work differs from undergraduate, in that the graduate student generally has a well defined idea of the field he intends to enter and consequently is ready for specialization. (2) The graduate student is required to carry forward some research problem to completion and to develop his ability to handle scientific methods and facts. Certain advanced courses are prescribed and required, but the chief emphasis is placed upon the ability to do independent, constructive work, in the use and application of the fundamental sciences.

Herein, then, lies the answer: Graduate work in horticulture consists of instruction and training in the application of the underlying sciences to the problems arising out of the cultivation of economic fruit-bearing plants or the disposition of the product. This presupposes a knowledge of horticultural materials, using this term in a broad sense, and also of the sciences. To apply a science it is necessary to know it.

Taking this view, then, toward graduate work, it will be clear that, while the materials of horticulture vary in different sections of the country, owing to climate and adaptation, the fundamental training in the sciences necessary to deal with the problems which arise, remains much the same. Here then in graduate work, the country over, we have a *constant*—scientific training—and even though the student is trained in one section, by means of the fundamental sciences, it is only necessary in taking a position in another section to become familiar with the materials, which alone, however, cannot be regarded as graduate work, but which can be easily accomplished after having been done for one region.

Preliminary Training for Graduate Work. In some of the papers read before this Society emphasis has been placed upon the lack of uniformity existing in the horticultural instruction given undergraduates. This condition has its bearing upon graduate work in that the undergraduate instruction in horticulture constitutes the preliminary training of most students who specialize in this subject and take advanced training.

The chief emphasis in the teaching work with undergraduates has been and will be directed toward training men who enter the commercial work. Much of this instruction has been primarily of a manual or trade nature. Such instruction, of university grade, can most effectively be given from the standpoint of the sciences underlying it, even to those students who plan to enter the commercial work. But what distinction, if any, shall be made in the course, particularly the junior and senior years, between the training given to those students who intend to enter the commercial work and those who enter teaching or research? This question is asked primarily from the standpoint of the preliminary training given to those who will take advanced training with the intention of specializing in horticultural research or teaching.

Our teaching efforts assume three phases in undergraduate instruction.

- (1) To train men who enter the practical or applied work.
- (2) To offer instruction to those students who take a general course in the applied subjects rather than the classics.
- (3) To train men who enter horticultural work from the standpoint of teaching, research, or extension.

It is with the latter class that we are primarily interested from the graduate standpoint and particularly those who enter teaching and research, yet much can be said of the training of the first two groups.

Since the teacher in horticulture generally does and should carry some research and the research man some teaching, the close relation between the two phases of the work is evident and needs no emphasis here. They are mutually stimulating and enlightening, consequently we need make little distinction, if any, between the undergraduate instruction for the prospective teacher and the investigator.

At best only general statements can be made which will be in accord with the experience of any number of institutions. While much attention has been given the proper mixture of theory and practice for the undergraduate, and we should give full value to the past experience, yet, after all the time element may indicate a different course in the future. It would certainly seem desirable for the student who can see his course, beyond his undergraduate days, to get the best training possible in the sciences, with special emphasis upon taxonomy, plant physiology, ecology, cytology, chemistry, physics, economics, genetics, languages, etc. Emphasis can be placed upon the botanical phases of horticulture by the instructor after the student has gotten a working knowledge of botany. The

weakness of most of our horticultural students has been in the fundamental sciences, particularly botany, and too much emphasis can not be given to these subjects within the time limits of the curriculum. With a proper grounding in the sciences, the applied work and studies of horticultural materials becomes easier.

The main point to be made with reference to the undergraduate training of students who intend to enter teaching or research is that greater emphasis needs to be placed upon the sciences. If this is done the student will not enter upon his graduate work with a handicap, but with a working knowledge of the forces and facts with which he is expected to deal.

The Laboratory Method. Emphasis must be placed upon the laboratory method of investigation; using this term in its broadest sense. Its continuance will accomplish for horticulture what it has for the other allied fields and the sciences from which it has been adapted. By means of the laboratory method graduate students will become more efficient with methods and apparatus and in time will acquire confidence in procedure and greater adaptability, which make easier a clear insight into the methods and proof of science.

Much of horticultural research can be undertaken by adopting the apparatus and methods of botany, especially physiology and ecology, chemistry, physics, etc., and the student investigator will gain much by a familiarity with the apparatus and methods of these sciences to be had by taking the proper courses in these underlying sciences. The use of these methods, however, will be greatly facilitated by familiarity with horticultural materials, which must be obtained from personal contact, the same as confidence in the use of apparatus.

Training by the laboratory method is what can be called a practical training, if we are to understand a practical training as one which will enable a man to fit into his environment, to see into the problems confronting the industry in his particular locality and to carry forward fundamental research. Such training should enable the student to carefully weigh results and evidence from the standpoint of their bearing upon truth and proof.

In emphasizing the applied or so-called practical work in horticulture, it must not be forgotten that training alone in this does little for those who enter the research work because the well trained investigator must know the applied or practical phase of the subject plus a thorough working knowledge of the fundamental underlying sciences. In other words it is necessary to know both the materials and the underlying sciences. Graduate research, as well as station research, carried forward with this viewpoint, even though in an applied field, will mean as much scientifically to the worker as the pure science subjects.

Relation Between Graduate Work and Station Research. The relation of the station men, or the men engaged in research work, to graduate work should not be overlooked. While the organization in the different stations and colleges renders this relation variable and in some prohibit the station men taking any part in graduate work,

yet, in most instances, men engaged in research work, whether their chief emphasis be placed upon this or upon the teaching, will profit by giving some attention to the direction of graduate students. Graduate work given in an atmosphere of research is effective and in most instances greater emphasis will be placed upon dealing with the facts of the fundamental sciences.

In those institutions where an intimate relation between graduate research and experiment station research can be maintained, it will, in most cases, be beneficial and stimulating to both. This relation will of necessity, owing to the time element, have to be limited more to minor projects, or, subdivisions of larger projects. Many projects of the station can be carried forward as thesis problems and worked out well within the time limits of either of the advanced degrees. Publication of the results, either as a station bulletin or in some journal, can be easily arranged with proper credit to all parties concerned.

From a number of standpoints this arrangement is desirable. (a) Some projects can be completed quickly at small expense. (b) The prospective specialist is given an opportunity to try his hand in his chosen field. (c) The results serve as a good index to the future promise of the student and can be used as his best recommendation to other institutions in securing a desirable position. (d) Incidentally the type of work done by graduate students is a good measure of the training and viewpoint of the department in which the work is done.

Factors Influencing Graduate Work. There are some influences operating at present which will assist much in raising the standard of graduate work in horticulture. Among these may be mentioned the relations of the departments of horticulture to the graduate school. In many of the larger institutions at least graduate work comes under the jurisdiction of a well organized graduate school with the result that it is often necessary to broaden the viewpoint and raise the standard, since the work given must be comparable to that given in the older scientific departments.

The general movement toward greater and more extensive activity in agricultural extension at present will increase the demand for reliable information along all lines, which can be taken to the practical worker. This will tend to free research from this demand and at the same time, by emphasizing it, will make places for an increased number of workers, who will naturally be selected for their training and experience in research.

In many lines of horticultural research the nature of the problems confronting the industry are such that specialized technical training is necessary for effective work. While men secured to carry on such research have not always been trained in horticultural departments, yet they bring the training and viewpoint to the department of horticulture. This is gaining for horticulture more recognition for this type of research, as well as training men for it. While it is not necessary ever to discriminate against the man who does not have an advanced degree, he, like others, must be measured by

his "performance record." The type of man who really takes his work seriously and who has the broadest conception of service is usually the one who equips himself by means of advanced training.

On the other hand there are some factors operating against placing graduate work in horticulture on a proper basis. Among these may be mentioned the viewpoint and training of a number of men with the so-called practical viewpoint and training who have little sympathy for technical training or research and who, consequently, do not foster either this viewpoint in their departments or tolerate it when introduced. This viewpoint, while in and of itself, cannot be condemned, has its chief influence, however, from its limitations and is perhaps more applicable to extension than to either teaching or research. This ultra-practical viewpoint is not often guided or directed by the results of research. While it will be recognized that this training is valuable in certain fields, it has not justified itself when placed in charge of departments or in the direction of research. In fact, much of the confusion in our teaching and research is a result of the lack of vision, in men of limited training.

In conclusion then, it will be found that when much of our past research is worked over in the light of new methods and training in many cases, no doubt it will be found wanting. From the teaching standpoint it has been difficult for the teacher to draw heavily on the results of research in horticulture as can be done in many other fields. This has no doubt made it possible, if not necessary in some instances, to place undue emphasis upon the applied or practical phase of the subject, especially where the subject has been unnecessarily subdivided into courses, leaving the student with the tacit impression that research and facts in horticulture are at least different from some other subjects with which he is familiar. This condition only serves to emphasize the need of careful training and research in the future.

We cannot assume in four years of undergraduate work and one or three years of graduate work to give a student all there is to be gotten in the way of training and viewpoint. After the degrees are taken, still there is much to learn and a would-be teacher or investigator is yet confronted with the proposition of making good. While it may be necessary for the student, upon taking a position, to limit his activities to a rather narrow field, it should not be necessary for him to narrow his sympathies or viewpoint. His interest in the larger problems should be maintained, along with that in the narrower field. His usefulness to his institution and his value to his science are largely determined by the ability to grow and broaden scientifically.

Confidence and poise in scientific work are only gained after long years of training and experience, but we shall have gone far toward placing the student in a position to make good if he is given the right viewpoint toward and the right conception of, the field he is to enter.

Finally, emphasis must be placed again and again upon fundamental training, as well as upon a knowledge of the material. Science, truth and proof are just the same in the applied fields as

in the pure sciences and this should be made clear to every graduate student. When full recognition is given to this, research will mean just as much scientifically in the applied fields as in the pure sciences, and the weakness of one-sided practical training will become more and more apparent.

RECENT WORK WITH "VITIS VINIFERA" IN NEW YORK.

BY U. P. HEDRICK, *Experiment Station, Geneva, N. Y.*

I need only remind this audience of the many efforts to grow European grapes in America. The various attempts, some involving individuals, others corporations and in early days even colonies, form some of the most instructive and dramatic episodes in the history of American agriculture. All endeavors, it will be remembered, were failures, so dismally and pathetically complete that we are wont to think of the 200 years from the first settlements in America to the introduction of the Isabella, a native, as time wasted in futile culture of a foreign fruit. The early efforts were far from wasted, however, for out of the tribulations of two centuries of grape-growing came the domestication of our native grapes, one of the most remarkable and one of the noblest achievements of agriculture. It is possible, too, that we may find that the failures of the fathers of American viticulture are the foundations for the success of the sons.

The advent of Isabella and Catawba wholly turned the thoughts of vineyardists from Old World to New World grapes. So completely, indeed, were viticulturists won by the thousand and more native grapes that came trooping in that for the century which followed no one has planted Old World grapes east of the Rockies, while vineyards of native species may be found North and South from the Atlantic to the Pacific.

Meanwhile, much new knowledge has come to agriculture, old fallacies have had many hard knocks and chains of tradition in which the culture of plants were bound, have been broken. In no field of agriculture have workers received greater aid from science than in viticulture. Particularly this is true of the diseases of the vine. The reports of the old experimenters were much the same, "a sickness takes hold of the vines and they die". What the sickness was and whether there were preventives or remedies no one knew a hundred years ago. But we have learned something about the ill grape flesh is heir to, with preventives and remedies for the same. We know that the early vine-growers failed in part at least because they followed empirical European practices. Is it not possible that in the last hundred years we have advanced sufficiently in our knowledge of plants, soils, insects, and fungi, and that by breaking away from European dictums we can now succeed in growing *Vitis vinifera* in eastern America where old experimenters failed? The Geneva Experiment Station is putting this question to test, with what result I am now to tell.

In the spring of 1911 the station obtained cuttings of 101 varieties of European grapes from the United States Department of Agriculture and the University of California. The object was to obtain European varieties to hybridize with American grapes. I hasten to say that at first there was no thought nor plan to experiment with these grapes as a cultivated crop. The cuttings obtained were grafted on the roots of a heterogeneous collection of seedlings five years set representing a half dozen species of *Vitis* and hybrids between them then growing on the station grounds. These stocks had little to recommend them except that all were vigorous, well established and all were more immune to phylloxera than the Old World varieties. From four to six grafts of each of the hundred varieties were made and a stand of 380 vines resulted, the percentage of loss being exceedingly small. The success in grafting we believe to be due to the method used, one the value of which had been proved in previous work on the station grounds.

In grafting the earth was removed from the plants to a depth of two or three inches. The vines were sawed squarely off below the surface of the ground. The stock was then split for a cleft graft. Two cions were inserted in each cleft and tied in place with waxed string. Grafting wax was not used, the wax being worse than useless because of the bleeding of the wounds in the stock. The earth was then replaced and enough more of it used to cover stock and cion to prevent evaporation from them. This method of grafting is available to those who have old vineyards. It is so simple that the veriest tyro can thus graft grapes. Were young plants or cuttings used as stocks some method of bench-grafting would, of course, be resorted to.

The cultivation and spraying have been precisely that given native grapes. There has been no codling of vines. The fungous diseases which helped to destroy the vineyards and vexed the souls of the old experimenters have been kept well in check by two sprayings with bordeaux mixture; the first application was made just after the fruit set, the second when the grapes were two-thirds grown. This year, 1914, a third spraying with a tobacco concoction kept thrips in check. Phylloxera is present in the vineyard but no one of the varieties on the resistant roots is appreciably suffering from this pest. It need hardly be said that the immunity to phylloxera secured by grafting is the chief reason for the success we are having with these grapes—undoubtedly this pest was the chief cause of the early failures. The stocks used in the present work are not those best suited either to the vines grafted on them or to resist phylloxera. Unquestionably some of the standard sorts used in France and California from *Vitis rupestris* or *Vitis riparia*, or hybrids of these species, would have given better results. From theoretical consideration it would seem that the *Vitis riparia* stocks should be best suited to the needs of eastern America.

It was thought by the old experimenters that *Vitis vinifera* failed in the New World because of unfavorable climatic conditions. It was said that the winters were too cold and the summers too hot

and dry for this grape. During the few years the Station vineyard of *Viniferas* has been in existence we have had stresses of all the kinds of weather to which the variable climate of New York is subject. Two winters have been exceedingly cold, killing peach and pear trees; one summer gave us the hottest weather and the hottest day in twenty-five years; the vines withstood two severe summer drouths and one cold, wet summer. These test seasons have proved that European grapes will stand our climate as well as the native varieties except in the matter of cold—they must have winter protection.

To growers of American grapes the extra work of winter protection seems to be an insuperable obstacle. The experience of several seasons at Geneva shows that winter protection is a cheap and simple matter. Two methods have been used; vines have been covered with earth and others wrapped with straw. The earth covering is the cheaper method and the more efficient. The vines are pruned and placed full length on the ground and covered with a few inches of earth. The cost of winter protection will run from two to three cents per vine. Since the European vines are much more productive than those of the American grapes the added cost of winter protection will be much more than offset by the greater yield of grapes. Trellising, too, is simpler and less expensive for the European grapes, helping further to offset the cost of winter protection.

It is apparent at once that European grapes must have special treatment in pruning if they are to be annually laid on the ground. Several modifications of European and California practices can be used in the East to bring the plants in conditions for winter laying-down. All methods of pruning must have this in common; new wood must be brought up from the base of the plant every second, third, fourth or fifth year in order to permit the bending of the plant. In our experiences we have no difficulties in so training the vines. Briefly, we have maintained for each vine two trunks, one old, the other young, which we have carried up to or just below the first wire in a two-wire trellis system and from each of these trunks we have trained a cane bearing from four to eight buds to right and left on a lower wire. The bearing shoots that grow from the buds on these canes are tied to the second wire. In a commercial vineyard, depending upon the varieties, our simple method might be modified in many ways to meet conditions.

The grower of European grapes grafted on American vines may be prepared to be surprised at the growth the vines make. At the end of the first season the grafts attain the magnitude of full-sized vines; the second season they begin to fruit more or less abundantly, and the third year they produce approximately the same number of bunches as a Concord or Niagara vine, and as the bunches of most varieties are larger than those of the American grapes the yield, therefore, is greater. The European varieties, too, may be set more closely than the American sorts since they are seldom such rampant growers.

It is quite too soon to reason from this short experiment that we are to grow varieties of *Vitis vinifera* commonly in New York, but the behavior of the vines on the Station grounds seems to indicate plainly that we may do so. At Geneva the European varieties are as vigorous and thrifty as American vines and quite as easily managed. Why may we not grow these grapes if we protect them from phylloxera, fungi and cold? In Europe there are varieties of grapes for nearly every soil and condition in the southern half of the Continent. In Eastern Europe and Western Asia the vines must be protected just as we shall have to protect them here. It seems almost certain that from the many sorts selected to meet the various conditions of Europe we shall be able to find kinds to meet the diverse soils and climates of this continent. And here, by the way, we have one of the chief reasons for wishing to grow these grapes—that American grape-growing may not be so localized as it now is. Probably we shall find that European grapes can be grown in more kinds of soils and under more various conditions than can our native varieties.

The culture of *Vitis vinifera* in the East gives us essentially a new fruit. If any considerable degree of success attends their culture then wine-making in Eastern America will be revolutionized for the European grapes are far superior to the native sorts for this purpose. Varieties of *Vitis vinifera* have a higher sugar and solid content than do those of the American species and for this reason as a rule keep longer and we may thus expect that through these grapes the season for this fruit will be extended. The European varieties are better flavored, possessing a more delicate and a richer vinous flavor, a more agreeable aroma, and are lacking in the acidity and somewhat obnoxious foxy taste of many American grapes. Consumers of fruit will like them better and the demand for grapes will thus be increased.

The advent of the European grape in the vineyards of Eastern America ought quickly to bring about splendid varieties of hybrids between *Vitis vinifera* and the American species of grapes. As all know, we have many such hybrids but curiously enough scarcely more than a half dozen varieties of European grapes have been used in crossing. Most of these have been greenhouse grapes and not those that could be expected to give best results for vineyard culture. As we come to know the varieties best adapted to American conditions we ought to be able to select European parents to better advantage than we have done in the past and thus produce better hybrid sorts.

From the eighty-five varieties of *Vitis vinifera* now fruiting on the Station grounds we may name the following as worth trying on a larger scale: Actoni, a table grape; Chasselas Golden, for the table; Cinsaut, for table or wine; Feher Szagos, another table sort; Kuristi Miei, for the table; Lignan Blanc, a very early table grape and one of the best; Mantuo de Pilas, Muscat Hamburg, Pinot Gris or Rüländer, three of the best table grapes; Poulsard, a wine and table grape; Palomino or Listan, a table and wine grape; Rosaki, a

table grape; Sultanina Rosea, a seedless table sort; and Teinturier, Petit Syrah, Franken Riesling and Zinfandel, all wine sorts.

I have briefly set forth the essentials of the work with *Vitis vinifera* in New York but I shall have missed an opportunity if this simple statement of facts ends here. Permit me to suggest several phases of the work in need of careful experimental attention.

First, it is imperative that we know more about the adaptation of European varieties to American conditions. More than a thousand varieties of grapes are grown in Europe and Asia but few of which have been tried in Eastern America. Those most promising for the different states should be carefully tried out.

Second, it is very certain that we shall have to grow European grapes on American stocks. We must determine experimentally what stocks are best for Eastern America; here the experience of European countries and California will be most helpful.

Third, a great obstacle in the way of growing European grapes in this region is the difficulty in getting a good stand of grafted plants. Possibly we shall have to modify the methods used elsewhere and to determine which will be best for us we must do experimental work in grafting and propagating.

Fourth, European varieties will be differently affected by fungi and insects than are our native sorts and it is possible that we shall have to modify remedial treatments of pests for the foreign grapes.

Fifth, there is a tremendous field for plant breeders in hybridizing European and American grapes. The half dozen European sorts that have been used in hybridization are for most part those that would be least expected to give good results, namely, greenhouse grapes. It is probable that the American grapes of the future will be European grapes with a dash of American blood in them. Plant breeders have a wonderful opportunity to breed grapes despite the fact that more work has been done with this fruit in the past hundred years than with any other.

In conclusion let me exhort those of you who have the opportunity to carry on experiments with European grapes. The work to be done is so vast that we cannot make an appreciable showing unless the task be divided among a number of workers. If horticulturists in the different stations will but concentrate on particular problems in the culture of *Vitis vinifera*, sifting the experience and knowledge of the world in regard to them for use under our conditions, it is almost certain that we can successfully grow some European grapes in Eastern America. Here, it seems to me, is a splendid opportunity on your part and mine to serve pomology.

METHODS AND RESULTS IN GRAPE BREEDING.

By R. D. ANTHONY, *Experiment Station, Geneva, N. Y.*

Grape breeding was first begun at the Geneva Station about twenty-five years ago. During this quarter century many members of the Society for Horticulture Science have assisted in the

work. Goff, Beach, Hedrick, Paddock, Close, Booth, Alderman, Dorsey and Wellington have at various times been responsible for the planning or carrying out of the various projects and during the last year the task of the speaker has been mainly, as Professor Hedrick would say, the sugaring-off of the sap they have gathered with such pains and effort.

BREEDING METHODS.

During these many years much has been learned by bitter experience and possibly a review of a few of these points may help others who are in the same or similar work. Probably the most important of these has been the change in the point of view of the work. The ultimate aim is, of course, the production of improved horticultural varieties. Through the early years when the knowledge of breeding laws and methods was more limited than now, this was not only the ultimate but, to quite an extent, the immediate aim of the investigators and the seedlings were usually subjected to a weeding-out process which seriously decreased the number of each cross planted in the test vineyards and made the interpretation of results difficult. Twenty years of seeking for new varieties by means of hundreds of crosses produced but one worthy of naming. This, together with a much better understanding of breeding fundamentals, lead to the conviction that the goal would be reached quicker by forgetting it, for the time being, and bending every effort to the discovery of those laws that underlie the inheritance of grape characters.

This change of viewpoint has resulted in almost a complete change of methods. The work is now developing along two lines; first, a study of the progeny of a large number of parental varieties to determine the potential heritage of these varieties and to discover, if possible, the existence of unit characters; and second, a careful review of all our breeding data to find and interpret breeding phenomena and the making of further crosses to clarify doubtful points.

One of the surprises in the study of varieties was the failure of so many of our commercial sorts to transmit desirable qualities to their progeny. Our best results have been secured from such little grown varieties as Ross, Collier, Mills, Jefferson, Diamond and Winchell. This makes it desirable to test all varieties that show any promise. The attempt to study as many varieties as possible has led us into a serious mistake in method. We have had that failing which seems common to most experimenters, we have tried to do more than could be done well. Plant breeding conclusions drawn from a small number of seedlings are at best of but doubtful value and this is especially true when we are dealing with so many factors as in our work with *Vitis*. A thousand seedlings from ten crosses are worth infinitely more than the same number from one hundred crosses. From a breeding standpoint, we have wasted half our time by growing too few seedlings of most of our crosses.

When a variety is self fertile the growing of pure seedlings greatly simplifies the study of its breeding potentialities. The Station has grown over two thousand such seedlings. These have aided much in our study of varieties and have thrown light upon the inheritance of various factors but they have been so uniformly lacking in vigor as to lead us to believe that selfing must be abandoned when we aim to produce improved sorts.

Our methods in the actual work of crossing are, I think, common to those of most breeders. The female blossoms are emasculated before the calyx cap splits off and are then bagged; the male blossoms are also bagged before the calyx splits. When the pollen is ripe, the bagged male cluster is usually cut from the vine and all or part of the cluster brushed over the emasculated female. Usually some of the male is enclosed in the bag which is again put over the female after pollination. In a few cases where the periods of blossoming of two varieties are widely separated, it has been necessary to save pollen in clean watch glasses or glass jars. It is customary to dip the forceps used in pollination into alcohol with each new variety. Certain results secured last summer would seem to indicate that this method is perhaps open to criticism. While emasculating clusters of Janesville, we found that although the cap had not split, the pollen in the anthers seemed to be mature and, as the anthers were ruptured in emasculating, there was a possibility of self fertilization. Several clusters were emasculated and bagged and left without pollination. These set nearly the full quota of berries with seeds which have every appearance of being viable. In the case of two other varieties, clusters emasculated and not pollinated matured a few plump seeds. An instance somewhat similar to this is reported by Beach in Bulletin 157 of this Station, the variety that time being Mills. This point deserves careful study for if it is found that serious danger of self pollination exists before the calyx cap is split, it will be necessary for us to change our methods—at least to the extent of doing the emasculating several days before the cap splits.

Another change of method which bids fair to be exceedingly important is in the type of parents selected for crossing. Although we are working primarily to determine breeding laws there is usually a wide choice of varieties which answer our purpose. Every indication points to the desirability of Vinifera blood in our grapes. With the growing of nearly one hundred different varieties of this species, we have been able to use several of these in our work and now have several hundred hybrids growing on the Station grounds. These will be increased by many hundreds during the following years.

RESULTS IN BREEDING.

Self sterility. Grape stamens are of two types, those having upright filaments and those in which the filaments bend backward and downward soon after the calyx cap falls off. The stamen type seems to be correlated with self fertility and self sterility. Beach found

that only those varieties with upright stamens were capable of producing marketable clusters when self fertilized and, from later work at the Station, it is probably safe to say that all varieties with upright stamens are self fertile though possibly in varying degrees. Reflexed stamens are always correlated with complete or nearly complete self-sterility. From a horticultural point of view, then, the problem before us is the elimination of the reflexed forms since self sterile varieties will always be at a disadvantage.

From many hundreds of seedlings we find that, when varieties with reflexed stamens are crossed, the progeny have upright and reflexed stamens in the ratio of 1:1; when reflexed varieties are crossed with upright varieties, the ratio is again 1:1; when upright varieties are crossed, in over a thousand seedlings, the ratio is 4:3 upright to 1 reflexed and apparently none of our upright varieties has proved pure for uprightness. Although we have crossed upright varieties by reflexed varieties many times and should have had hundreds of seedlings of this cross growing, but one plant has survived the vicissitudes of the seed bed and nursery to be planted in our test vineyard. In the last five years, fifty crosses have yielded 600 seeds and now in our nurseries from these we have but twenty-five seedlings living. The cause of the nearly complete failure of this cross is an enigma. From these results it would seem that at present we have no way of eliminating reflexness. We may, however, keep down the proportion of reflexed varieties by crossing among the upright sorts.

The Inheritance of Sex. The inheritance of pure males is interesting. Less than one hundred males have been found in over 6,000 seedlings on the Station grounds. Of these we have complete records for but sixty-two. Fifty-one of these sixty-two have come from crosses in which the pollen parent was a pure male. This leaves eleven males recorded as produced by pollen from hermaphrodite plants. Five of these came from one cross, the other six from five crosses. These six were probably females, erroneously recorded as males, an error very easy to make. Probably the parent yielding the five males was an intermediate recorded as a female. Such an intermediate, having both male and hermaphrodite blossoms, has been under observation on the Station grounds and its pollen seems to behave as the pollen of a pure male. In other words, it is reasonable to assume that, excluding these intermediate forms, pollen from the hermaphrodite plant will never produce pure males. When pure male pollen is used we get practically a 1:1 ratio of males and females.

Inheritance of Skin Color. Grape colors are not sharply differentiated and because of this our search for pure colors has been greatly complicated. So far, we have been able to formulate but two general laws, namely, that white is a pure color and that it is recessive to both black and red. With but one possible exception, no black variety that has been tested to an extent sufficient to make the results at all conclusive has proved pure. Some blacks have a factor for different shades of red, others seem to contain only black and its

absence, white, while still others have both white and red progeny. The various shades of red are equally as mixed in their color composition, ranging all the way from black to white.

Size of Berry. A study of the progeny of a large number of parental varieties has failed to show dominance of any one size. If Mendelian laws enter into this problem we must grant that size is the result of the interaction of several factors. In no other way could we account for the wide variations even among pure seedlings. There is, however, a strong tendency for a variety to produce a population whose mean value is approximately that of the variety. Thus as we go from crosses involving large berries to those of small berries there is a steady decrease in the value of the mean from above medium to small.

Form of Berry. We have three distinct shapes; oval, round and oblate, but they blend together through so many intermediates that there is no sharp line of demarcation. The pronounced oval shape of many *Vinifera* grapes will probably be found to be a pure form recessive to the roundness of most of our American grapes. The oval form which we find in a few natives and in many *Vinifera* hybrids is probably an intermediate between roundness and some more pronounced oval. It is this latter, less pronounced oval to which we refer when we use this term in American grape culture. Very few grapes are distinctly oblate. One of the most so is Goff, a seedling originated at this Station. The behavior of pure seedlings of Goff would seem to indicate that, in this variety at least, oblateness is a pure form probably recessive to round. With the exception of oblate, all parental types have given progeny whose modal class falls under round, showing the extent to which this form tends to obscure oval and oblate.

Season of Ripening. Here again, we have no apparent indication of dominance of any one season. There is a tendency, however, for a variety to reproduce its own season. Thus, crosses of early varieties yield seedlings whose mode falls in the early season with a mean a little later, while crosses of late sorts give a mode at early mid-season with the mean somewhat later.

Inheritance of Quality. We have made parental combinations that run the entire gamut of quality. The most noticeable thing that shows in the study of the progeny from all these combinations is the very low percentage of seedlings whose quality is good or above good, even when parents of the highest quality were used. A moment's reflection shows us that this regression is what we should expect. Our American grapes, except for the *Vinifera* hybrids, are but a step removed from the wild with but few possessing sufficient quality to make them stand out from the many thousands too poor to be eaten with relish. In breeding from these we are breeding from the topmost point of the species and the effect of the immediate wild ancestors is to pull the progeny down toward the level of the species.

Although only about a half dozen varieties of *V. vinifera* have been used to any extent for hybridizing, practically every grape in

our vineyards which ranks high in quality possesses some of the blood of these varieties. The clue to this predominance is evident when we consider the history of the species. European grapes are centuries removed from the wild and have been subjected to a more intense selection than any other fruit. "The level of mediocrity" has been raised to such a point that the species has become a powerful factor in transmitting high quality. In this connection it is well to speak again of the future which lies ahead of the breeder who will search out and use those varieties of this potent species which blend best with our hardy native varieties. The ages of selection and breeding in Europe have developed varieties of this one species adapted to nearly as wide a range of climate as is covered by all our native species taken together. The field for this work is large and the promise of harvest is good.

In studying our pure seedlings we find that they are uniformly lower in quality than crossed seedlings of varieties of similar quality. This loss is probably caused by the decreased vigor of the pure seedlings.

CONCLUSIONS.

The time and effort spent upon grape breeding at Geneva would seem to have had but meager reward since, up to this fall, only one seedling had been named. Now we have named five very promising seedlings and we hope this means that the work of the last twenty-five years has given us methods and materials out of which in the next twentyfive years we may make a substantial addition to viticulture in New York.

A FERTILIZER EXPERIMENT WITH PEACHES.

BY C. A. McCUE, *Experiment Station, Newark, Delaware.*

This report is given largely because of request and not because of the speaker's inclination. I realize that the work under discussion is very incomplete, as the experiment has run but seven years; and a period of seven years is too short a time to accurately gauge the physiological effects of commercial fertilizers upon fruit trees.

A little over seven years ago the Delaware Experiment Station conceived the idea of endeavoring to ascertain the physiological rôle of potash, nitrogen and phosphoric acid in peach and apple production. The general plan devised to accomplish this was to conduct the experiment in two parts. The first part was an orchard experiment to run from 10 to 15 years with peaches and 25 years with apples. The second part was a pot experiment with peach trees, to duplicate the field treatments and to run 10 years.

In casting about for a method to grow peach trees in pots, we found, after a thorough search of the literature, that, excepting one small experiment in France, there were no precedents to go by. In using pots, or pits, as perhaps they should be called, it seemed necessary to provide for ample room for the tree to develop, so after

considering many plans, it was at last decided to construct them out of concrete. These pits, 40 in number, were built 5 feet 3 inches deep and 12 feet in diameter and drainage was provided by sloping the floor. In order to control as far as possible the plant food for the trees, these pits were filled with as uniform and as poor a soil as we were able to get; this was building sand dredged from the bottom of Delaware Bay. The concrete construction work was completed during the Autumn of 1908 and the pits were filled with sand during the Spring of 1909. In order to allow as much soluble plant food as possible to leach out, the filled pits were left unplanted until the following Spring.

Just before the trees were planted, soil samples were taken from each pit and analyzed by the station chemist. These soils contained from 94.16 to 96.16 per cent of oxide of silica, .420 to .624 per cent of organic matter, .009 to .031 per cent of nitrogen, .019 to .180 per cent of P_2O_5 , .314 to .855 per cent of K_2O , .100 to .570 per cent of CaO , .115 to .450 per cent of MgO , .71 to 1.27 per cent of Fe_2O_3 , .071 to .580 per cent of Na_2O , .98 to 2.53 per cent of Al_2O_3 , and .034 to .171 per cent SO_3 . These figures show that the soil was a remarkably poor one in so far as soluble plant food was concerned. The widest variation was in the amounts of potash and sodium, but this was to be expected because the sand was of potash spar and soda spar origin.

A very uniform grade of nursery-grown Elberta peach trees was procured and these trees were pruned alike in both root and top. All soil clinging to the roots was carefully washed away and the trees were air-dried in the shade for about an hour. They were then carefully weighed and planted, one to each pit. Several accidents have since happened and three or four pits have been replanted. Two trees were saved for chemical analysis. Fertilizers have been applied every year since at the unit rate of 50 pounds per acre for each element. The various food elements have been derived from nitrate of soda, muriate of potash and acid phosphate. Two pits have had their potash allowance supplied in the form of sulphate. The applications were applied in duplicate. An attempt was made to catch and analyze all drainage water but it was found impractical to do so. The drainage waters from seven pits have, however, been saved since this experiment started. These waters have been weighed, sampled and analyzed. However, the results are not satisfactory as it was soon found that contrary to our expectations some of the pits were leaking, and that severe winters have caused others to crack. In view of our experience with concrete pits, I would advise any of you who are considering similar pit experiments to use some other material than concrete. Probably a steel alloy such as is used in spray tanks would answer the purpose. Our work is faulty also because there is no way of regulating the water table in the pits and this may prove a very serious defect in experiments of this nature.

The trees in the pits have never been pruned. The leaves have been carefully collected from each tree each year and analyzed.

In fact, we have tried to get a record of every possible place where the utilized plant food was finally deposited. So far, we have been unable to collect the petals, calyxes and dead buds.

From the standpoint of crop records these trees have been a disappointment for there have been three crop failures due to either late frost or low winter temperatures, and up to date only two or three peaches have been harvested off the entire 40 trees.

However, we have duplicated the pit experiment with an orchard planting and have had some very suggestive results from three partial crops of fruit. Frost, winter temperatures, exposure, and air and water drainage, have proven serious disturbing factors in our orchard work, but, nevertheless, some results are so clean cut that we feel we must accept them at their face value.

The orchard experiment was laid out in a series of 24 blocks, each block being five trees square. In order to guard against the effect of cross feeding from one block to another, the records have been taken from the nine center trees on each block and there have been seven annual applications. Of the twenty-four blocks, five are checks and have received no fertilizers. The fertilizers have been used on the unit system of 50 pounds or multiple of 50 pounds of each element per acre.

Effects of cross feeding have been observed in only one case, block 10, which is so located that there has undoubtedly been some leaching of nitrogen from the block above it. Block 19 lies in the lowest corner of the orchard and is too wet for best peach production. All of the cold air of the field drains on to this block and as a result it has suffered severely from spring frosts and winter freezes and so far as fruit production is concerned should be thrown out of the calculations.

The nitrogen used has been derived from nitrate of soda; the potash from muriate of potash and the phosphoric acid from either 14 or 16 per cent acid phosphate. All blocks had an application of 500 pounds per acre of hydrated lime when the trees were three years old. The cover crop each year has been oats.

All blocks have been pruned and trained as nearly alike as possible and all prunings from the record trees have been carefully weighed. The greatest quantity of prunings has been taken from the blocks receiving nitrogen.

Careful observations have been made of the effect of different fertilizing elements upon color. This work is as yet incomplete, but our tentative conclusion is that any effect of nitrogen, potash or phosphoric acid upon color, is secondary. The blocks heavily fertilized with nitrogen have been deficient in color, but this defect has been due to the profuse growth of foliage shutting off the light from the fruit. The potash blocks have had practically the same intensity of color as the check block. There is a suggestion that heavy applications of phosphoric acid may have a deadening effect upon color. These blocks while apparently having as much color as the potash or check blocks, have at the same time lacked in sprightliness of color.

The color seemed to lack life and character. The effect is hard to describe in words, but I think that you will catch my meaning.

In general the health of the trees is characterized by greenness and freshness of foliage. Plots that were treated with nitrogen or combinations of nitrogen and potash are characterized by their general thriftiness. No diameter measurements have been made from year to year as it has been considered that a careful study of the annular rings after the trees have been cut down will give much more accurate data.

The tests for keeping quality of the fruit from the various plots are as yet incomplete, but such tests as have been made seem to indicate that potash has some beneficial effect in increasing the period of soundness of the fruit. However, this point needs further testing to confirm it.

In time of ripening of the fruit we obtained striking results. Heavy phosphoric acid applications delayed ripening about two days and potash hastened it one day. Nitrogen either in combination or alone delayed ripening from a week to ten days. The power of nitrogen to retard ripening is much stronger than that of potash to hasten it, so that when nitrogen and potash are combined the hastening effects of potash are almost wholly over-shadowed by the retarding effect of the nitrogen.

So far as the effect of fertilizers on the time of blooming is concerned we have seen but little if any result. The total period of bloom is so short that the differences in blooming dates are minor ones and might be accounted for by other reasons. We suspect, however, that the effect upon the blooming period is similar to that upon the date of maturity, although the proof of it is not yet clear.

We have no very clear and definite results upon the time of wood ripening in the fall for which the terminal bud formation has been used as a guide. It is generally supposed that heavy applications of nitrogenous fertilizers would make a soft immature wood, but our results, though inconclusive, would appear to refute this view. It is probable that the regulation of the soil moisture has a more intimate connection with fall ripening of wood and bud than does plant food.

No definite conclusions have been formed upon the effect of fertilizers on the color of twigs. Light here, as in the fruit, appears to be the most important factor.

No work has as yet been done upon flavor, it being thought to limit this to fruit grown in the pits.

From several years' work in testing out pollen from the various blocks we are inclined to believe that the plant food does have an effect upon the viability and longevity of pollen, but I do not feel ready to make a definite statement upon this point. However, from some preliminary work in pollinating the flowers upon the various blocks with pollen taken from a tree outside the experiment, I am inclined to believe that heavy applications of phosphoric acid have a tendency to lessen the set of fruit, but whether this results from faults in the mechanics of fertilization of the embryo nucleus or

from abnormalities in the embryo sack, or from mechanical defects in style or stigma, I am unprepared to say. This point needs considerable further study.

Table I shows the yields in baskets of fruit per acre from the various blocks during the past three years.

TABLE I.

Plot	Treat- ment	Yields Per Acre in Baskets.			
		1912	1913	1914	Total
1	K	348.00	236.00	180.4	764.4
2	O	432.80	96.50	313.2	842.5
3	K ₂	708.61	333.48	523.8	1565.9
4	P	410.16	82.72	469.8	962.7
5	O	199.47	78.52	225.7	503.7
6	P ₂	53.31	00.	771.2	824.5
7	O	18.43	43.16	559.4	622.0
8	KP	122.31	348.96	368.3	839.6
9	N	171.75	179.16	1859.8	2210.7
10	O	244.20	80.90	703.1	1028.2
11	NK	471.21	135.60	2144.9	2751.7
12	NP	269.83	.24	1211.8	1481.9
13	K ₂ P	7.86	206.52	710.6	925.0
14	KNP	18.33	231.36	740.9	990.6
15	KN ₂ P	206.01	458.88	1348.9	2013.8
16	N ₂ K	526.00	331.58	2095.2	2952.8
17	N ₂ P	556.56	106.80	1782.0	2445.5
18	O	381.79	1.20	432.0	815.0
19	NK ₂ P	57.60	53.04	137.2	247.8
20	O	6.84	34.80	252.7	294.3
21	NKP ₂	80.22	520.08	977.4	1577.7
22	NK ₃ P	324.30	478.80	1226.9	2030.0
23	N ₃ KP	551.14	183.60	1971.4	2706.1
24	NKP ₂	244.40	21.60	1671.4	1937.4

The most striking fact brought out in this table is the effect of nitrate of soda upon fruit production. There seems to be little danger of over feeding the peach with nitrogen in the form of nitrate of soda; what would be the effect of applying equal amounts of nitrogen from organic sources I am unprepared to say. Block 23 has had an annual application of nitrogen equal to about 1000 pounds of nitrate of soda for the past seven years and has been one of our heaviest yielders during the past three years. Block 9 has had nothing but nitrate of soda for the past seven years yet in 1914 the crop averaged over nineteen baskets per tree. Blocks 11 and 12, and 15 with 16 are worthy of comparison since they show that nitrogen and potash are the most important elements in the peach food supply and that phosphoric acid is relatively unimportant.

The effect of nitrogen is to give dense foliage, prodigious growth, a full set of buds, good pollination, a smaller average size and poor color of fruit. Many of the bad effects of nitrogen could probably be overcome by judicious thinning and summer pruning. As the aim of this experiment was to gauge the possibilities of fruit formation from different fertilizer elements, we have never done any consistent thinning of the fruit.

Potash, while a vital element in peach production, must be coupled with nitrogen to give best results. The splitting effect of nitrate of soda upon insoluble potash in the soil, may possibly account for the remarkable results obtained from block 9 although acid phosphate is also supposed to possess this quality to a marked degree.

The practical results as manifested in net returns per acre, after deducting the cost of fertilizers are shown in table II.

TABLE II.

Plot	Treat- ment	Cost of Fertilizer per Acre for 7 yrs.	Total Gross Receipts per Acre 3 crops	Net Receipts per Acre
1	K	\$ 17.50	\$ 587.20	\$ 569.70
2	O	.....	577.60	577.60
3	K ₂	35.00	1125.90	1090.90
4	P	17.50	624.90	607.40
5	O	.....	340.65	340.65
6	P ₂	35.00	425.58	390.58
7	O	.....	336.68	336.68
8	KP	35.00	625.34	590.34
9	N	59.50	1237.87	1197.37
10	O	.....	614.55	614.55
11	NK	77.00	1562.46	1485.46
12	NP	77.00	1008.53	931.53
13	K ₂ P	52.50	567.71	515.21
14	KNP	94.50	615.59	521.09
15	KN ₂ P	154.00	1287.84	1133.84
16	N ₂ K	136.50	1773.68	1637.18
17	N ₂ P	136.50	1415.09	1278.59
18	O	.....	503.62	503.62
19	K ₂ NP	112.00	648.82	536.82
20	O	.....	166.28	166.28
21	KNP ₂	112.00	1068.92	956.92
22	K ₃ NP	129.50	1335.45	1205.95
23	KN ₃ P	213.50	1782.65	1569.15
24	KNP ₃	129.50	1040.60	911.10

In brief it may be said that the larger the amount of nitrogen used per acre the greater was the financial returns upon the investment.

THE HUMIDITY FACTOR IN ROSE CULTURE.

BY M. A. BLAKE,

Experiment Station, New Brunswick, N. J.

Rather definite statements and rules are given by florists for the regulation of temperature in the forcing of the various varieties of roses in greenhouses. Detailed statements are not infrequently published also, giving directions for the selection and preparation of the soil previous to benching the plants and for the fertilization of the plants after benching. Yet comparatively little is ever stated or written as to the relation of humidity to the growth of the rose plant. It proves to be a most important factor, however, and one which is not infrequently the one cause of failure in the securing of a crop.

Relative humidity or the percentage of moisture in the air has a direct effect upon the character of the growth of any plant. If the humidity of the air about a rose plant is high the foliage tends to become large and to remain flexible and glossy for a considerable period. On the other hand if the humidity is low the foliage becomes smaller, hardens quickly as it develops, and is more dull in appearance.

The florist desires a vigorous, glossy, flexible foliage upon his rose stems and such foliage denotes that the plants have been well grown.

Every plant undoubtedly has an optimum air humidity above or below which the best results cannot be secured. Every florist knows that the maiden hair fern will not succeed in a dry atmosphere, neither will the cactus succeed in a very moist one.

Varying degrees of humidity have a marked effect upon one's sensibilities. A greenhouse at a high humidity feels several degrees warmer than one at a low humidity even though the temperature may be exactly the same in each house.

The trained florist may not be able to define just what air conditions he considers ideal for any particular variety of rose, but he passes through the houses, "wets down" walks, opens or closes ventilators, and turns on or shuts off certain heating pipes according to his impression of the air conditions in the houses. In other words he is a human thermometer and psychrometer combined and may be as accurate in his determinations as the best of instruments.

There is no reason, however, why the optimum humidity for any variety of rose may not be determined as accurately as temperature.

The rose investigations at the New Jersey Agricultural Experiment Station have provided the opportunity for some observations of the effect upon the plants of varying degrees of humidity. The observations have shown that the humidity may vary to a marked extent in different parts of the same greenhouse. In one instance a difference of 8 per cent in humidity was noted between two points less than 33 feet apart in the same greenhouse. Temperature and humidity were found to be closely associated as would be expected.

An increase in temperature tended to lower the humidity when there was any evaporation from the house.

EFFECT OF HUMIDITY UPON KILLARNEY ROSES.

The effect of too low a degree of humidity upon the Pink Killarney Rose was most marked at New Brunswick. The foliage "hardened off" too quickly as it developed, the new shoots set bud too quickly and were not free enough in their growth, the buds were short, the flowers too single and they opened too rapidly.

The behavior of the sepals of a Killarney bud served as a good indicator of relative humidity. When the humidity is low the sepals remain close about the bud until it opens, but when the humidity is high the sepals expand outward from the bud several days before the flower is ready for cutting. Under high humidity the petals lengthen considerably before they expand, while under low humidity the flower opens quickly and the petals are short. Mildew was also much more prevalent and very difficult to control under low humidity.

When the humidity ranged from about 60 to 70 per cent during the fall and winter months Killarney failed to grow and develop properly, but when it was maintained at about 80 per cent a fine growth and crop resulted.

A word of caution should be given here. A humidity of 80 per cent is too high if the temperature is excessive and if the soil is quite moist, and may result in prompt and serious loss of foliage. Roses upon soil with a high water holding capacity are affected most quickly. A fine adjustment of these three factors is necessary for best results.

During the summer months the humidity outside the greenhouse may range from 35 to 40 per cent upon fair days at New Brunswick. It is impossible to maintain a humidity of 80 per cent in the greenhouse and keep the temperature down. If September is abnormally warm rose growers often have more difficulty in maintaining the desired growth. September is called a period of "between seasons" by florists. Following the benching of the plants in May or June the houses are freely ventilated to keep down the temperature and to promote a strong growth. But after constant cool weather occurs in November, less ventilation is given, the humidity is increased and true forcing begins. If unusually warm days occur after this period careful attention must immediately be given to watering, heating and ventilating.

EFFECT OF HUMIDITY UPON COLOR OF FLOWERS.

It has been stated that high humidity promotes a softer and more flexible plant growth. Excessive growth upon fruit trees is commonly at the expense of the color of the fruit even when it is fully exposed to the sunlight.

When such varieties of roses as White Killarney first bloom in the Fall when the humidity of the greenhouse is low the petals commonly show a cream or even pink shade of color, while later in the season when the humidity is high the petals are greenish white at first, but as the bud becomes fully developed, the petals are pure white. It may be claimed that this is the result of less sunlight. Lack of sunlight results in a weaker, more succulent growth as is the case with excessive humidity and it is true that sunlight is necessary for high color, but high color and finish will not be secured even in bright sunlight if the growth of the plant is too succulent or weak. With bright days and a humidity of about 80 per cent a house of Pink Killarney was brought to maturity at the New Jersey station in the Fall of 1914. The color of the first flowers cut was the normal pink of the variety. The florist, Mr. D. M. Jobbins, then reduced the percentage of humidity slightly and the flowers became as deeply colored as Killarney Brilliant. The decrease in humidity resulted in a slower development and an increase in color. Rate and character of growth are undoubtedly factors which affect the color of flowers and fruit to a considerable extent as previously reported before this Society.

Humidity is a factor, however, which must be varied with caution in the rose houses. If lowered suddenly it may bring on an attack of mildew, shorten the buds and result in poor flowers. On the other hand a sudden change from a low humidity to a high one in the presence of a high temperature may result in loss of foliage.

WHAT DETERMINES THE HUMIDITY IN THE GREENHOUSE.

In order to maintain a relatively high humidity in a heated greenhouse the evaporation of water vapor from the interior of the house to the outside air must be checked. Even in a "tight" house, and with the ventilators closed there is some evaporation of moisture or drying out of the house when the outside humidity is low. With the ventilators open and the heat turned on in the pipes, evaporation is likely to become rapid and the humidity decreases accordingly.

In the summer months with the ventilators all open to reduce the temperature it is impossible to maintain a humidity much above 50 per cent. In the winter months when the heating pipes are shut off during bright days and the ventilators are open but little, it is not difficult to keep the humidity above 70 per cent.

To secure humidity in the greenhouse there must be a supply of moisture to convert into water vapor. This is supplied by the wetting down of the benches and walks in the house. If the walks are of concrete they will require frequent wetting or the humidity will run low. Soil or cinder walks will make the maintenance of a high humidity quite easy during the forcing season.

The method of heating and ventilating the houses will directly affect the degree of humidity aside from the character of the walks and benches and the amount of moisture applied to them.

The humidity factor as affecting greenhouse crops deserves more attention from both the scientist and the practical grower.

HEREDITY STUDIES WITH THE CARNATION.

By C. H. CONNORS, *Experiment Station, New Brunswick, N. J.*

Hybridizing, so-called, of the carnation is being carried on by a large number of commercial growers of this plant, on a more or less extended scale. This work is of the "hit-or-miss" variety of breeding, based on the possibility of a promising seedling appearing in the first or second generation. No records, or, at best scanty ones, are kept, the result being that it is almost impossible to trace back the heredity of any of the promising commercial varieties for more than two or three generations.

Of late years, there have been a number of scientific investigators who have worked with the carnation with the result that certain characters are found to follow the Mendelian law of inheritance. Stuart¹ working at the Vermont Agricultural Experiment Station and Arlington Farm, and Norton² deduced that there are two true "types" of carnation bloom, the single and the double, and that the commercial type is really the fusion of the heterozygous gametes of the single and the double. Single crossed with single gave all singles; commercial crossed with single gave approximately one-half singles and one-half commercials; commercial crossed with commercial gave about one-fourth singles and three-fourths commercials and doubles; singles crossed with doubles gave practically all commercials.

This classification of bloom is arbitrary. The writer³ found that some of the so-called singles might have six or seven petals and petaloid organs; the commercial varieties might have up to 168 petals and petaloid organs; while what have been called "bull-heads" might have anywhere from 100 to 475 petaloid organs.

A suggestion of the rule to follow in the classification of the flowers of the carnation would be to call a flower with a single whorl of petals up to eight in number, a single; a flower with a long bud and calyx having more than eight petals and less than one hundred, a commercial; and a flower having a globular bud and more than one hundred petaloid organs, a double or bull-head. It was found that certain commercial varieties would vary greatly in the number of petals under varying cultural and seasonal conditions.

Assuming these standards, the seedlings grown at the New Jersey State Experiment Station in 1912-13 bear out the findings of Stuart, even though the number of individuals with which we worked was small. The seedlings that year were all the result of crosses between commercial varieties of carnations.

Out of one hundred and eighty-three seedlings that bloomed, fifty-two were single, eighty-one were commercial, and fifty were double, a reasonably close approach to the Mendelian ratio, considering the fewness of the individuals. In addition to these, there

¹Vermont Agricultural Exp. Sta., Bul. 163.

²Proc. Soc. Hort. Soc., p. 105 (1905).

³Proc. Soc. Hort. Sci. p. 93, 1913.

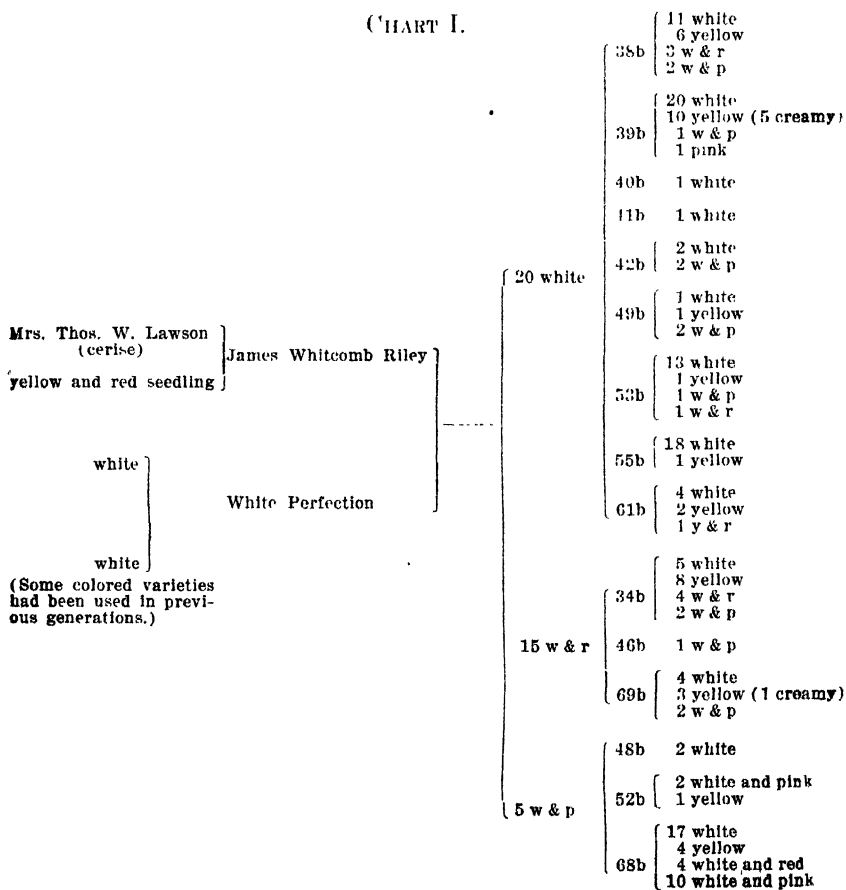
were two plants that bore both single and double flowers and two that bore both commercial and double.

The object of all breeding investigations, aside from the technical points involved, is either to secure better varieties or improved strains of existing varieties.

So the object in breeding carnations has been mainly to secure flowers of better color and better form. The absence of complete records in this breeding work makes the correlation of the results more difficult, because of the lack of knowledge of the parents of existing varieties, and because different colors have been used indiscriminately.

There have been no good commercial varieties of yellow carnations, so the idea was conceived at the New Jersey Station of working for a good yellow one. James Whitcomb Riley, one of the best yellows up to that time, but lacking in vigor, was selected for the seed parent and White Perfection for the pollen parent. The descent of these, so far as is known, is shown in Chart I.

CHART I.



SUMMARY OF CHART I.

9 whites	$\left\{ \begin{array}{l} 71 \text{ white} \\ 21 \text{ yellow} \\ 1 \text{ yellow and red} \\ 4 \text{ white and red} \\ 8 \text{ white and pink} \\ 1 \text{ pink} \end{array} \right.$	3 white and pink	$\left\{ \begin{array}{l} 19 \text{ white} \\ 5 \text{ yellow} \\ 4 \text{ white and red} \\ 12 \text{ white and pink} \end{array} \right.$
3 white and red	$\left\{ \begin{array}{l} 9 \text{ white} \\ 11 \text{ yellow} \\ 4 \text{ white and red} \\ 5 \text{ white and pink} \end{array} \right.$	Totals	$\left\{ \begin{array}{l} 99 \text{ white} \\ 37 \text{ yellow} \\ 1 \text{ yellow and red} \\ 12 \text{ white and red} \\ 25 \text{ white and pink} \\ 1 \text{ pink} \end{array} \right.$

All that could be learned was that White Perfection came from a cross between white parents, but other colors had been used in previous generations. According to Mendel's law, however, the white was supposed to be pure. James Whitcomb Riley was from a cerise parent on one side and an unknown yellow and red seedling on the other side.

Mr. D. Manley Jobbins crossed flowers of these two varieties in 1911, and the seedlings bloomed in 1912-13. Of these, twenty were white while twenty were variegated, fifteen with red and five with pink. This proved white dominance in the first generation.

Nine of these "pure" whites were self-pollinated, yielding one hundred and six individuals.

HYPOTHETICAL PAIRS INFLUENCED BY IMMEASURABLE STIMULI.

The combinations of characters possible in each gamete are as follows:

W Y R = White,
 W Y r = White,
 W y R = White,
 W y r = White,
 w Y R = Yellow, (?)
 w Y r = Yellow,
 w y R = Red,
 w y r = ? (either white, red, or a dilution).

The number of variations possible is sixty-four.

CHART II

WYR	WYr	WyR	Wyr	wYR	wYr	wyR	wyr
WYR	WYR	WYR	WYR	WYR	WYR	WYR	WYR
WYR	WYr	WyR	Wyr	wYR	wYr	wyR	wyr
WYr	WYr	WYr	WYr	WYr	WYr	WYr	WYr
WyR	WYr	WyR	Wyr	wYR	wYr	wyR	wyr
WyR	WyR	WyR	WyR	WyR	WyR	WyR	WyR
WYR	WYr	WyR	Wyr	wYR	wYr	wyR	wyr
Wyr	Wyr	Wyr	Wyr	Wyr	Wyr	Wyr	Wyr
WYR	WYr	WyR	Wyr	wYR	wYr	wyR	wyr
wYR	wYR	wYR	wYR	wYR	wYR	wYR	wYR
WYR	WYr	WyR	Wyr	wYR	wYr	wyR	wyr
wYr	wYr	wYr	wYr	wYr	wYr	wYr	wYr
WyR	WYr	WyR	Wyr	wYR	wYr	wyR	wyr
wyR	wyR	wyR	wyR	wyR	wyR	wyR	wyR
WYR	WYr	WyR	Wyr	wYR	wYr	wyR	wyr
wyr	wyr	wyr	wyr	wyr	wyr	wyr	wyr

Variations possible in the second generation, S.P., of a cross between a white and a yellow carnation, red being present.

W = dominant white ; w = recessive white.

Y = dominant yellow ; y = recessive yellow.

R = dominant red ; r = recessive red.

If white be dominant when homozygous, then all of the combinations in quadrant I are white. If white be dominant when heterozygous, no matter whether yellow and red be homozygous or heterozygous, then all the combinations of quadrants II and III will be white. This gives the number of whites at 75 per cent of the total.

If, in the same way, homozygous or heterozygous yellow be dominant over either homozygous or heterozygous red, then 75 per cent of the remainder will be yellow or quadrants IV₁, IV₂, IV₃ will be

yellow. This leaves only quadrant IV₄ in which three combinations may be taken as reds. The fourth, w y r—w y r, is an indeterminate and may be any one of the three colors, a dilution, or a composite, such as a variegated.

The proportions then should be:

75 per cent white.....	79.5	white.
18.75 per cent yellow.....	19.9	yellow,
4.68 per cent red.....	4.96	red,
1.57 per cent indeterminate.....	1.66	(?).

The actual figures are 71 white, 21 yellow, 1 yellow and red, 4 white and red, 8 white and pink and 1 pink. Putting it in another way there are 71 white, 21 yellow and 13 red.

This shows the yellow to be about the expected number. The whites are a little under the expected number and the reds a little over. The proportions, however, may be taken as fairly consistent, since the multiplication of factors such as variegation have been neglected, and since the number of individuals is so small.

The Mendelian law of inheritance of color is that when white occurs, it should breed true. This assumption has not been entirely borne out in this experiment. The behavior of certain individual whites would seem to indicate that there are two forms of whites. Just as there might be a homozygous red or a heterozygous red, as found by Hedrick⁴ in studying the inheritance of color in the skin of the apple, so there might be a homozygous white or a heterozygous white. This would seem to be partially borne out by the behavior of the progeny of certain individuals. No. 39 b when self-pollinated gave twenty white, ten yellow (of which five were diluted or creamy), one pink and one white and pink. No. 38 b when self-pollinated gave eleven white, six yellow, three white and red, and two white and pink. No. 55 b gave eighteen white and one yellow.

Working with so small a number of individuals makes the correlation with the law difficult. While there is not enough evidence to substantiate the suspicion that there are two kinds of whites, the indication points strongly in that direction, and it is hoped that we shall be able to prove it in the study of subsequent generations of this cross.

Heritable characters that hinder or limit the work are found. James Whitcomb Riley is usually imperfect, so that it is impossible to obtain the reciprocal of the cross. It was observed, however, that toward the end of the season a few flowers of this variety appeared that had streaks of red and these variegated flowers bore pollen, though it was not very virile. This character of imperfect sexual nature is transmitted to the progeny. So far as has been observed, no pure yellow from this cross has been perfect, only two yellows bearing stamens, one the yellow and red and the other very dilute yellow or cream. Among the whites of this cross, too, this defect is inherited. In the first generation, fourteen seedlings were im-

⁴N. Y. Geneva St. Bul. 350.

perfect and in the second generation, fifty-seven. This makes the difficulty of close-pollination rather greater than usual.

A few of the variegated individuals in the first generation were self-pollinated, the result being:

28 white	41 per cent
16 yellow	23 per cent
8 white and red	{
17 white and pink	}.....36 per cent

The use of variegated individuals brings into the combination complicated factors that need further study, but the result so far would seem to indicate the dominance of the white over red and yellow. However, the presence of the strong red character seems to reverse the dominance of yellow and red as found in the clear whites, and makes red dominant over yellow, as expected.

SUMMARY.

The results of this investigation so far tend to show that in crossing a yellow carnation with white, red being present as a latent character:

1. White is dominant over yellow and red.
2. In the second generation, yellow will be dominant over red unless the red be strongly evidenced, in which case red is dominant over yellow.
3. In some yellow carnations the presence of red is associated with the presence of perfect sexual organs.
4. The probability of two kinds of white, homozygous and heterozygous, as dominants is strongly suspected.

WEDNESDAY, DECEMBER 30, 1:30 P. M.

The meeting was called to order by President Corbett and a short business meeting was held.

The officers and committees for 1915 as given on page 5 were elected.

A committee of three members on graduate work was added to the standing committees on horticultural courses.

It was decided to hold the annual 1915 meeting at Columbus, Ohio, during convocation week in December. This meeting will cover two days of two sessions each. The members were in favor of continuing the smoker as an annual event.

The trip to and through California and the Summer meeting in connection with the Panama-Pacific Exposition, will be considered a field trip for the members and the Executive Committee and Secretary were instructed to prepare a program for a one-day meeting only to be held at the University of California.

EXPERIMENTAL RESULTS IN YOUNG ORCHARDS IN PENNSYLVANIA.

By JOHN P. STEWART, *Experiment Station, State College, Pa.*

As most of you doubtless know, an extensive series of orchard experiments was started by the Experiment Station, in various parts of Pennsylvania, in 1907 and 1908. The results from some of these experiments, especially those on the fertilization of mature orchards, have been published from time to time in bulletins and reports of various organizations. In the meantime, results have been accumulating in a number of other experiments, some of which differ considerably in subject from those already reported. The latter results for the most part are coming from young orchards which were planted expressly for use in the present series of experiments. Neither experiments nor results are regarded as complete in any sense, but they are presented at this time to show the trend of affairs for the first seven years, and to furnish some additional definite data in a field and period of development that is now relatively bare.

The first data to which we could call attention are upon the comparatively old question of the relative merits of different methods of propagation for young apple trees. Which is the best type of tree to plant, one propagated on the whole root, by budding or grafting, or is one developed on a piece root, or without any seedling root at all, equally good or superior? This was a very live question some 15 or 20 years ago, and a number of experiments were made on it, chiefly at the Kansas, Pennsylvania, Oregon and Alabama stations. The last three of these experiments were practically identical, the grafts being made by the Federal Division of Pomology in 1895 and the resulting trees sent to the stations for planting in 1897.

Those sent to the Pennsylvania station consisted of 10 varieties of Hungarian apples, with two trees of each variety grafted on whole roots, two on top piece and two on bottom piece roots. They were planted on April 15 and 16 by the late Professor Butz, and cared for uniformly until the date of measurement by the writer in April, 1908, exactly 11 years after planting. Two trees were out on the latter date, one each in the first and third groups, and one additional tree in the bottom-piece group was so dwarfed and "runty," as a result of defective union, that it was excluded in the final averages. The average growth made in the various groups, ten varieties of six each, in 11 years, is shown in Table I.

TABLE I.
INFLUENCE OF METHOD OF PROPAGATION UPON GROWTH OF
APPLE TREES.

Kind of Graft	No. of Trees	Average Trunk Girth Inches	Average Height Feet	Gain in Girth Per cent	Gain in Height Per cent	Rank
Whole Root..	19	15.85	13.86	0.2	0.4	2
Top Piece....	20	16.12	14.10	1.9	2.2	1
Bottom Piece.	18	15.82	13.80	...	...	3

In this case it will be noted that the trees propagated on the top piece roots are slightly in the lead in all respects, with those on the whole roots coming second. In the experiment in Alabama, as reported in their Bulletin No. 98, the trees on the bottom pieces were showing a slight superiority at the close of the second season, with those on the top piece second and the whole roots third. In the Oregon experiment, as stated in the Annual Report for 1901, pp. 38 and 39, the trees on the whole roots were slightly ahead at the close of the fourth season, in the single variety remaining at that time, with those on the top piece again second.

In the Kansas experiments reported in their Bulletins No. 65 and No. 102, 64 trees grafted on whole roots averaged just one-tenth of an inch larger in trunk diameter at the end of 10 years' growth in the orchard, than 30 trees that had been budded in the usual manner on whole roots. They in turn averaged a fifth of an inch larger than 102 trees, involving some additional varieties, that had been propagated on piece roots. No differences in growth or vigor were observable in the orchard. In another experiment in the same state and reported in Bulletin No. 65, 3 varieties of 400 trees each, on whole roots, were compared by Judge Wellhouse with an equal number of trees of the same varieties propagated on very short piece roots, 2-inch lengths. In the latter case a very considerable number of roots developed from the scions above the seedling pieces, thus making trees on their own roots to a considerable extent, while none were developed on the whole root trees. At the end of 19 years of growth in the orchard the only difference observed was that a much greater number of sprouts had come up from the whole-root trees than from the others. No other noticeable difference, either in growth or fruiting had appeared.

From all this data it is obvious that no one of the present forms of propagation has any material advantage over any other. It may be of distinct advantage to get rid of the seedling root altogether, either by using the shortest pieces practicable and then cutting them off entirely during the process of transplanting after roots have developed above, or possibly by a direct rooting of the scions by the use of a method that it is rumored will soon be made known by the Federal Bureau of Plant Industry. This elimination of the seedling root would at least diminish the numerous ill-effects of poor unions. It would also reduce the opportunity for crown-gall infection, eliminate the possibility of harmful influence of the variable seedling stock upon the scions, and would furnish really standard roots, as well as tops, with which the injuries from root-aphis and kindred difficulties might well be greatly reduced or eliminated entirely. This is plainly an important array of advantages, and all of them practical and by no means impossible of attainment. Who will be the fortunate one to carry this matter through?

ON THE VALUE OF SCION SELECTION.

The next question is somewhat related to the one just considered but is much more recent in origin. It bears upon the value of

scion selection, including the so-called "pedigreed" trees, and also incidentally including the existence of the so-called drone trees. In this question we are seeking to determine whether or not it is possible to materially affect the yield, or any other important quality in an apple tree, by selecting the scion which produces it from a tree which is known to possess the desired qualities to an unusual degree.

Various theories and observations have been advanced on this question and a few experiments have been conducted, most of which are summarized by the writer in the Annual Report of the Pennsylvania Experiment Station for 1910-11, pages 493-500 and 505-6. The net results of all this observation and discussion, however, have merely shown that important variations do exist among mature trees, in almost any direction desired, *but thus far none of the variations within a variety have been actually proved to be heritable*, with the apparent exception of color. In addition the most fundamental and generally accepted theories are all against such inheritance, without excepting color.

With this situation in view, we started a preliminary experiment in 1908 to test the actual heritability through scions of such individual superiorities as we were able to locate, chiefly through the aid of commercial orchardists. This experiment to date has shown some slight indication of a possible advantage in the process of scion selection, but neither our data nor any other now available is sufficient to justify anyone in paying any materially higher prices for the so-called pedigreed trees. Such trees probably have more certainty of trueness to name where the scions have recently come from mature trees of known bearing habits, and one is naturally on the safe side of the question in using them when they can be obtained without material increase in price. This, however, is all that can be said in favor of the practice at present, and much further data are needed.

RELATIVE VALUE OF CERTAIN STOCKS IN TOP-GRAFTING.

In case any of the experiments on scion selection should definitely prove the practice to be advisable, it will evidently be well to know something of the relative values of different stocks available for use in top-grafting. Some desirable varieties also should regularly be top-grafted to secure better and healthier trunks. To secure data on the relative merits of certain well-known varieties for stock purposes a test was started in 1908, using four trees each of three varieties on five different stocks, with the results shown in Table II.

TABLE II.

INFLUENCE OF DIFFERENT STOCKS ON GROWTH OF
YOUNG APPLE TREES.

(Average increase in trunk-girth 1908-1914, Exp. 334.)

Jonathan Tompkins King Grimes

Plat	Stock	Average Gain Inches	Average Gain Inches	Average Gain Inches	General	
					Average Gain in Size Inches	Lowest Per cent
1	Northern Spy ...	7.99	6.71	7.25	7.32	11.4
2	Tolman	6.79	6.82	8.60	7.40	12.6
3	Wolf River.....	6.25	6.37	7.09	6.57	....
4	Paragon	9.22	8.56	8.75	8.84	34.5
5	Champion	7.29	6.78	7.83	7.30	11.1
6	Nursery Trees...	8.33	6.62	6.09	7.01	6.7

One rather unexpected result here appears in the fact that in all cases except one, the trees top-grafted on known stocks, have made a better growth than those grafted on seedling roots in the nursery. In the case of the Grimes also, all of the top-grafted trees are now in the lead. Among the different stocks the trees developed on the Paragon are now distinctly in the lead, with those on Tolman coming second. With the Grimes and Tompkins King, which are the only ones of these three that really need top-working, the superiority of these two stocks is very marked so far as growth is concerned. On the smoothness of unions, the Tolman and Champion are probably best, with the Paragon next, if the Jonathans be excepted, as in that variety the Paragon stock has tended to outgrow the scions. Incidentally the reverse is the case with Grimes on Wolf River.

The Northern Spy stock has averaged third in growth and is now running about equal to the Paragon in unions. It also usually makes an excellent trunk and root-system, but in at least one respect it is considerably less desirable than either the Tolman or Paragon for stock purposes, and that is in its unusual fardiness in starting growth in the spring. This tends to make the scions of most varieties more active than the stock, which is naturally the reverse of the condition desired when the grafts are being started. From the present results, either the Paragon or Tolman appears to be distinctly preferable to any of the others for Grimes at least, with the Champion coming in third, if the Jonathans are omitted.

Some further interesting relations between certain stocks and scions used in top-grafting have also been reported orally to the writer by Samuel Fraser, of Geneseo, N. Y. He finds, for example, that the Twenty-Ounce top-grafted on Baldwin makes from 50 to 100 per cent better trees in five to eight years than when worked on Northern Spy. Similarly he finds that the Wealthy does very poorly on Rhode Island Greening, while the latter does very well on Wealthy. Hubbardston top-grafted on Ben Davis, Northern Spy,

and Tolman resulted in such peculiar changes in twig color—some becoming red, some purple, etc.—that they could not be used with safety for further scion wood until they had proved their identity by coming into bearing.

These and similar facts indicate that many of the common variations in size and vigor so frequently shown by the same variety of trees, both in their nursery and later growth, are due to differences in congeniality between the scions and the variable seedling roots on which they were worked. Moreover, the very remarkable effects of certain types of grafting, which result in the plant chimeras and graft hybrids (see *Journal of Heredity* for Dec., 1914, pp. 521-546), also indicate that there is still a vast amount to be learned about all these matters, which again brings us back to the desirability of reducing all variable factors, such as seedling stocks, to the lowest terms possible.

ON THE VALUE OF DYNAMITING IN APPLE ORCHARDS.

This question was naturally not considered of fundamental importance, but there was so much agitation and so many inquiries about it that it seemed desirable to get some definite data on it also. For this purpose four experiments were started in the western part of the state, on a Volusia silt loam which had a typical hard-pan sub-soil at an average depth of about 10 to 14 inches. Two of these experiments were on orchards just being planted, and two on 25-year old Baldwins which had become more or less sod-bound. They were started in the Spring of 1912 by W. R. White of the college, and all the records have been taken by him under the general direction of the speaker. The net results of the two experiments in young orchards at the close of the third season, 1914, are shown in Table III.

TABLE III.
INFLUENCE OF DYNAMITING ON GROWTH AND VITALITY OF
YOUNG APPLE TREES.

Experiments in:	White Orchard	Johnston Orchard
No. of trees dynamited (A).....	34	25
No. of trees not dynamited (B)....	19	10
Depth of explosions.....	2 to 4 ft., by 6 inch intervals	Same
Average gain in trunk girth, A.....	2.01 inches	2.491 inches
Average gain in trunk girth, B.....	1.98 inches	2.486 inches
Benefit to growth in A.....	1.5 per cent	0.2 per cent
Total trees dead, A.....	8 or 23.5 per cent	0
Total trees dead, B.....	2 or 10.5 per cent	0 (1 weak)

In both these cases we find a very slight superiority in growth in favor of the dynamited trees, but nothing of any importance. In fact the difference is so very small that it is necessary to go to the third decimal place to find it in the Johnston orchard, and in the

other orchard the much higher death rate among the dynamited trees more than offsets the slight superiority in growth. In fact, the difference in death rate seems to be the only definite effect that has appeared here so far, as the growth differences are so small that they may be directly chargeable to normal variations. Similar results on the apple are reported from both the New Hampshire and New Jersey stations, and the general absence of effects in the thorough, mechanical, sub-soiling test that was started at the Missouri station in 1895 and reported in 1900 in Bulletin 49, should all lead to the conclusion that nothing important is likely to be gained in this direction.

In the mature orchards, the results for three years, 1912-1914, are shown similarly in Table IV.

TABLE IV.

INFLUENCE OF DYNAMITING ON YIELD, GROWTH, COLOR AND AVERAGE SIZE OF FRUIT ON MATURE APPLE TREES.

Experiments in:	Boak Orchard	Johnston Orchard
No. of trees dynamited (A).....	5	5
No. of trees not dynamited (B)....	5	5
Depth of explosions.....	2 to 4 ft., by 6-inch intervals	Same
Total yields, in A.....	3986 lb.	5654 lb.
Total yields, in B.....	5136 lb.	5332 lb.
Benefit to yield in A.....	22.4 per cent	6.0 per cent
Benefit to growth, A.....	4.9 per cent	-0.7 per cent
Benefit to color of fruit, A.....	0.4 per cent	-12.4 per cent
Benefit to average size of fruit in A..	-7.3 per cent	10.1 per cent
No. of fruits in samples.....	1189	939

Here again the results are so variable as to cause one to suspect that the dynamiting has had little or no definite influence at all. The net effect in both experiments is rather against the shooting instead of in favor of it. At any rate, none of the present results would indicate any special value in the practice of dynamiting in apple orchards at least, and the same is true of the definite experimental results elsewhere, so far as the writer is aware. Incidentally, there is plenty of really definite and profitable uses for dynamite to make it unnecessary to try to force it into a field for which it is not fitted.

ON METHODS OF HANDLING THE SOIL IN A YOUNG ORCHARD.

The next three experiments bear upon the various methods of handling the soil in an apple orchard from date of planting up to the age of seven years. The first and third experiments are chiefly concerned with the relative values of different cultural methods and cover crops, while the second also furnishes some data on the relative values of different fertilizer combinations.

The data shown in Table V are obtained from the experimental orchard at the college. In this experiment the area now covered by plats 2 and 6 was plowed in the fall of 1907, and prepared about as for corn in the spring of 1908 when all the trees were planted. Since then the different methods named in the table have been followed annually.

In the meantime, in plats 7 to 9, no tillage of any kind has been given. The trees were merely planted in the rather thin sod in holes dug with a spade, and then were mulched with about 100 pounds of straw per tree. Since then the growth between the trees has been cut at least twice annually, and the material obtained in the first cutting has been added to the mulch, while the second cutting left where it fell. In addition, the initial mulch of outside materials has been repeated about every other year. The results of this experiment, No. 331, at the close of seven years, 1908-14, are shown in Table V.

TABLE V.

INFLUENCE OF CULTURAL METHODS ON MOISTURE, GROWTH AND
YIELD IN A YOUNG ORCHARD.

Plat	Treatment	Moisture Content 1913 per cent	Relation to Optimum Content per cent	Average Gain in Girth inches	Gain Over Tillage per cent	Total Yield pounds	Gen- eral Rank
2	Tillage	10.6	53.0	6.84	....	1.5	8
3	Tillage and inter crop...	5.5	27.6	7.69	12.4	21.6	6
4	Tillage and cover crop.	8.5	42.7	6.84	....	7.0	7
5	Cover crop and manure..	9.2	45.9	8.31	21.5	135.4	3
6	Cover crop and fertilizer.	9.4	47.2	7.76	13.5	18.9	5
7	Mulch	17.1	85.6	8.29	21.2	38.5	4
8	Mulch and manure.....	18.2	90.8	8.76	28.1	300.5	2
9	Mulch and fertilizer....	18.1	90.4	8.93	30.5	390.1	1

In the first place it will be noted that the least growth is being made in plats 2 and 4. The annual cover crop which consists of a mixture of red and crimson clover, has therefore shown no benefit to the trees as yet. The use of a tilled annual inter crop in plat 3, followed by a late cover crop of rye, has not only resulted in no apparent injury, but the associated trees are actually making about 12½ per cent more growth than those under either of the more usual treatments in plats 2 and 4. Similar results are observable in the experiment shown later in Table VI, and similar results were also obtained by Emerson at the Nebraska Station and reported to the close of the second year in 1903, in Bulletin 79, pages 14 to 17.

The financial returns from the inter crops in our experiments, with such crops as potatoes, have usually run from \$40 to \$50 per acre even on the very poor soil involved. The inter cropping method therefore is evidently by far the most practical of any of those involving tillage, and no important injury should result to the associated trees so long as proper inter crops are used. By

proper inter crops we mean those involving some early season tillage each year. If in addition the trees themselves can be kept mulched with a good coat of strawy stable manure, such benefits as those shown in plat 5 can be secured.

Where tillage and inter crops are not feasible however, the mulch system is available and has proved very effective, as shown in plats 7 to 9. The results there also are in accord with those in the following table, and with those reported from the Ohio station in Bulletin 171. The special success of the mulch is evidently due to its unusual effectiveness in conserving moisture. As shown in the second column, the roots of the mulched trees were still surrounded with 85 to 90 per cent of the best possible moisture content in September, 1913, after fully six weeks of very unusual drought, while the soil around the roots of the tilled trees had been reduced to a dust-dry condition in most cases.

The addition of plant food in plats 8 and 9 has resulted in some gain over the mulch alone, but from the relative growth made it would seem that the conservation of moisture is fully twice as important as applications of plant food, at least in the case of young trees. The latter applications, however, have apparently had considerable influence on the yields, which is rather surprising in view of the fact that the trees are so young. Incidentally the usual correlation between yield and growth is especially prominent here, and this again emphasizes the fact that early bearing cannot be secured on young healthy trees without an extra amount of growth.

TABLE VI.

INFLUENCE OF FERTILIZATION AND CULTURAL METHODS ON GROWTH AND YIELDS IN A YOUNG ORCHARD, FIRST SEVEN YEARS.

Plat	Treatment	Average gain in trunk girth inches	Gain over normal growth per cent	Yields 1914** pounds
1	Check	6.64	....	32
2	Nitrogen and phosphorus.....	7.59	11.8	62
3	Nitrogen and potash.....	6.96	0.3	10
4	Check	7.09	...	0
5	Phosphorus and potash.....	7.69	6.2	17
6	Complete fertilizer	8.67	11.4	28
7	Check	8.18	....	37
8	Manure	8.77	10.0	23
9	Lime (and NPK, 1912-).....	8.18	5.3	17
10	Check	7.56	...	10
11	Tillage and cover crop.....	7.38	1.5*	19
12	Tillage and inter crop.....	7.79	7.2	50
13	Clean tillage	7.27	....	23
14	Sod mulch	8.11	11.6	109

In Table VI we have results from experiment No. 337 started at the same time as the last, on volusia silt loam in the western part of the state. This experiment differs slightly in the fact that the cul-

*Gains over lowest in the cultural method section.

**Reduced to equivalent plats throughout.

tural methods and fertilizer treatments are entirely separated, and the latter treatments are so enlarged that the relative values of the different fertilizer elements can be determined to some extent. Just at present, however, its chief value is in the general corroboration that it gives to the results in the preceding table.

In the cultural plats 11 to 14, the greater growth and bearing in the mulch and inter crop treatments are again quite evident. In the fertilizer portion of the experiment, the growth has been improved somewhat more than usual by certain elements, viz., nitrogen and phosphorus. This is probably connected with the fact that this particular soil type is usually deficient in these two elements. In general also, it is very well supplied with moisture which probably accounts for the relatively smaller effect of the mulch in this case.

RELATIVE VALUE OF COVER CROPS.

When these experiments were started we naturally expected the tillage and cover crop method to rank high among the soil treatments, and especially was this expected in young orchards. To get some data therefore, as to which cover crops were best for this purpose, experiment No. 333, shown in Table VII was started in 1908. Along with the comparison of annual covers used in plats 1 to 12, a single permanent cover was included in plat 13, and the material annually produced between the rows was used as a mulch around the trees. The results to the close of the seventh year, 1914, are shown in Table VII.

TABLE VII.

INFLUENCE OF COVER CROPS ON GROWTH AND YIELD OF YOUNG APPLE TREES.

Plat	Treatment	Average increase in girth inches	Gain over lowest per cent	Estimated bloom 1914 per cent	Yield 1914 pounds	General rank
1	Medium red clover.....	7.60	13.1	0.3	0.00	8
2	Mammoth clover	7.17	6.7	0.0	0.00	11
3	Alsike clover	6.85	1.9	0.2	0.00	12
4	Crimson clover	7.77	15.6	0.2	1.25	7
5	Hairy vetch	8.07	20.1	0.5	0.50	3
6	Cowpeas (black)	6.72	0.0	1.0	0.00	13
7	Soybeans (Hollybrook) ..	7.98	18.8	0.2	0.00	5
8	Oats and Canada peas...	7.93	18.0	1.5	0.00	6
9	Rye	7.52	11.9	0.2	0.25	9
10	Millet	8.02	19.3	0.3	1.25	4
11	Rape and turnips.....	7.29	8.5	0.2	0.50	10
12	Buckwheat	8.15	21.3	0.1	0.50	2
13	Alfalfa (used as mulch)..	8.83	31.4	15.0	8.75	1

In this case also it is a notable fact that the mulched and un-tilled trees associated with the permanent cover of plat 13 are again in the lead. In addition to this, the alfalfa has produced all the mulching material required and some surplus besides, especially in the earlier years. The mulching moreover, has always been heavy enough to keep down practically all growth immediately above the

majority of the feeding roots of the trees, and this is probably essential for best results with this plant as the permanent cover, because of its special affinity for both moisture and soil nitrogen.

In a good alfalfa soil, however, it is quite possible to get an abundant mulch of this sort and still have a considerable surplus of good hay besides. In other words this particular method gives us a mulch and something of an inter crop at the same time, without any tillage and without any apparent injury to the trees, where the mulching and protection against mice are both sufficient.

This it will be observed is a relatively new idea in orchard development and the present method, or some modification of it, is evidently very well adapted for large acreages, or for places where tillage and inter crops are not available.

A similar new idea is suggested by the results in the adjoining buckwheat plat. Its trees are now showing the best gains of any of the annual tillage treatments. This may be due partly to a slight advantage that it apparently has in location, but without that advantage, the buckwheat would evidently still rank high. It is also probable that the general good effects of this plant are not dependent in any way upon the return of the grain to the soil. It therefore could well be harvested by heading or high cutting and thus give the unusual example of a combined cover crop and inter crop, which also exerts no apparent ill-effect on the trees. This crop, moreover, is especially good where an orchard is being developed on so-called new ground, and a crop is desired to keep down the second growth of sprouts and underbrush.

The vetch continues to show a better effect on the adjacent trees than any other of the annual legume covers. This is not surprising when its nitrogen-fixation, its shading habit of growth and its very low moisture demands are recalled. This plant also has considerable promise for use as a permanent cover and mulch producer. It usually forms an abundance of seeds by the middle of July or earlier, after which it can be cut and left where it lies for reseeding, and then be brought up around the trees as a mulch. Running over the loose vetch with a roller or similar implement before raking it around the trees may assist in shelling out the seeds where they are needed, and a light disking or harrowing after the raking should be helpful in increasing their germination.

Among the non-leguminous plants the high rank of the millet and buckwheat is still evident, and the same is true of rape when used alone. We are unable to give any very satisfactory explanation for this, but the facts themselves are sufficient to attract favorable consideration to their use as cover crops, and this is especially true when their relatively low cost of seed is considered. The buckwheat is probably best from the economic standpoint as noted above, but the millet is very satisfactory where this use of buckwheat is not available.

The seeding rates, relative cost in 1914, and general dates and methods of seeding that we have followed in the annual cover crops are shown without further comment in Table VIII.

TABLE VIII.
RATE OF SEEDING AND COST OF COVER CROP SEED IN 1914.

Crop	Cost of seed		Cost of seed per acre	Date of seeding	Method
	Pounds per acre	per pound in cents			
Crimson clover.....	20	6.5	\$1.30	July 15-20	Broadcast and harrowed
Medium red clover.....	12	15	1.90	" "	" "
Mammoth clover.....	15	15	2.25	" "	" "
White clover.....	5	30	1.50	" "	" "
Alsike clover.....	6	17.5	1.05	" "	" "
Sweet clover.....	25-30	25	5.25 to 7.50	Jan. to May	" "
Hairy vetch.....	40	7 to 12.5	2.80 to 5.00	July 15-Aug. 15	Drill or broadcast
Canada peas.....	60-90	.....	.....	" "	" "
Cowpeas (black).....	50-60	5	2.50 to 3.00	June 25-30	Drilled
Soybeans (Hollybrook).....	40-50	4.5	1.80	" "	" "
Rye.....	90	1.3	1.17	Sept. 1-Oct. 15	Drill or broadcast
Oats.....	75	1.5	1.13	July 15-Aug. 15	" "
Millet.....	20	4	80	" "	" "
Buckwheat.....	1 bu.	3	1.50	July 4-10	" "
Essex rape.....	8	6	.48	" "	Broadcast and harrowed
Cowhorn turnips.....	4	25	1.00	" "	" "

OSMOTIC RELATIONSHIPS AND INCIPIENT DRYING WITH APPLES.

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The importance of the proper adjustment of the water supply in fruit trees comes to be recognized more as experiments in fruit culture progress. Thus, experiments with tillage show that not only may insufficient water supply result in the reduction of the size of the tree, and thus necessarily a reduction of the crop that it may bear; but with trees of equal size, the one in sod and the other under tillage, the tree in sod may set very much smaller crops, perhaps not only because of the greater tendency to alternate, but also because there seems to be a reduced percentage of set with a given bloom. On the other hand, Müller-Thurgau has shown that in some cases the June drop consists of fruits that have been pollinated, and fall apparently only because of excess water supply. While soil conditions represent the largest factor in determining the water supply to fruit, yet the nature of the tree also is a rather important factor. Thus, *Ewart has shown that the resistance to the movement of water in the sap wood as rapidly as it must move to replace the water transpired by the leaves, is equal to the force of a column of water from six to thirty-three times the length of the wood through which the water passes. Unquestionably there may be tissue in which the resistance is even much greater than this. **Renner has recently added much to our knowledge concerning the movement of water in plants. He finds a suction in the stems that may be equal to the calculated osmotic strength of the cells of the leaves, provided the leaves are sufficiently wilted that the entire osmotic strength may be applied. With saturated leaves the suction is of course small, but under normal conditions neither the leaves nor the stems are ever fully saturated. When leaves that have been transpiring rapidly are immersed in water the suction continues until the leaves become saturated. When transpiration is increased suddenly the water intake is increased only gradually. The introduction of resistance increases the suction. Negative pressures, which amount to several atmospheres, may remain in the stems for some time after the leaves are removed. High negative pressure would not be equalized by suction of air, but only by intake of water.

*Ewart, A. J.—The Ascent of Water in Trees. Trans. Roy. Soc. London, Sec. B, 198:41-85 (1905); 199:341-392 (1908). *Annals of Botany*, 24:85-105 (1910).

**Renner, O.—Experimental Beiträge zur Kenntnis der Wasserbewegung. *Flora* Vol. 103:171-247 (1911).

—Versuche zur Mechanik der Wasserversorgung. *Ber. Deutsch. bot. Ges.* 30:376-580 (1912).

****Kraus**, in 1882, showed apparently that in case both of fruits and of woody tissue the volume decreased during the day and increased only at night or during rainy days. Last year I presented a paper in which it was shown that the osmotic strength of the leaf is much greater than that of the fruit, these osmotic strengths being measured by means of freezing point determinations of expressed sap. In the light of Renner's work we should expect as a result of this that as the suction toward the leaves increased on account of transpiration during the day (that is, unless the leaves are able to absorb water fully as rapidly as they transpire it) they should tend to draw the water from the fruit; and where there are large resistances in the tree, such as restrictions due to a slow growth, especially in the twigs to which the fruit is attached, we should expect rather large suction to develop. If the growth of the fruit is dependent somewhat on its having a rather continuous water supply so that at approximately all times it approaches saturation, an extremely large leaf surface, especially where there are large resistances, should tend perhaps at times to reduce the size of the fruit. I cited experiences to indicate that in practice this phenomenon may sometimes be observed.

*Livingston has shown that under desert conditions there may be a fairly large reduction in the percentage of water in the leaves that would not be readily detected by the appearance of the leaves; in other words, an incipient drying. During the past season Mr. A. J. Heinicke and I have been conducting some preliminary studies concerning incipient drying of both leaves and fruit of the apple at Ithaca, N. Y. Leaves were gathered at varying times of the day and placed immediately in weighing bottles with ground glass stoppers, and weighed and dried to a constant weight in an electric oven. Moisture determinations of the fruits were made generally by taking three apples that apparently represented about the average size from the tree, a sample from each apple being cut with a cork borer from the surface to the core and put in each of three bottles. Later, three or more additional samples were taken and placed in bottles each bottle containing the tissue from one apple only. Thus, the error due to the difference in moisture content of different apples could be separated from error in taking, drying and weighing the samples.

The first samples, leaves only, were taken on June 24. In the samples taken at 8:30 A. M. the average moisture content was 63.1 per cent; in those taken at 12:00 M. the average content was 62.6 per cent; in the samples taken at 5:30 P. M. the average moisture content was 64.07 per cent. Shortly before the last sample was taken there was a light shower of rain so that the leaves contained

****Kraus, Gregoe**—*Über die Wasservertheilung in der Pflanze. Die tägliche Schwellungsperiode der Pflanze. Abhandl. d. naturf. Ges. zu Halle. Bd. XV, p. 231-319 (1880-82).*

*Livingston, B. E.—*The Relation of the Daily March of Transpiration to Variations in the Water Content of Foliage Leaves. Bot. Gaz. Vol. 53:309-330.*

a higher moisture content than those taken at 8:30 in the morning. It could be seen that there was slight incipient drying. These leaves were taken from a Fallawater apple tree that was under good cultivation, and had been severely pruned in the spring so the water supply was exceptionally good.

On July 17, leaves and fruit were taken from a very old Tompkins King tree which stood in sod, so that in addition to the ill effect of the sod there were probably large resistances to water movement in the wood. However, the tree had been pruned rather thoroughly during the previous winter. The following table gives the results obtained:

MOISTURE CONTENT OF LEAVES.

Time samples were taken	Average percentage of water in leaf four determinations	Reduction in percentage of water	Probable error
4:30 A. M.	63.80	....	.07
9:45 A. M.	62.39	1.41	.09
12:30 P. M.	60.82	2.98	.44
3:45 P. M.	61.65	2.15	.21
6:00 P. M.	64.50	increase .70	.60

MOISTURE CONTENT OF FRUIT.

Time samples were taken	Average percentage of water in fruit four determinations	Reduction in percentage of water	Probable error
4:30 A. M.	88.60	....	.05
9:45 A. M.	88.36	.24	.11
12:30 P. M.	88.10	.50	.06
3:45 P. M.	88.13	.47	.06
6:00 P. M.	88.15	.45	.04

It will be seen that there are fairly large incipient dryings in the leaves and appreciable incipient drying in the fruit, yet the evaporation was not large on the day these samples were taken. At 3:45 P. M., when next to the last samples were taken the weather was becoming cloudy, and it will be seen that the moisture content was going up slightly, while just before the samples were taken at 6:00 P. M., there was a fairly heavy rain, and the moisture content of the leaves was somewhat larger than at 4:30 A. M., though all moisture was rubbed from the surface of the leaves. It is interesting to observe that though the leaves regained their normal moisture content when the atmosphere became humid, the fruits continued with their reduced moisture content even up to 6:00 P. M., though perhaps there was slight rise in moisture content by that time. While the difference in the case of the fruits seems small, the probable error is also small, and it should be considered that since the

moisture content of the fruit is so large it requires a very large loss of water to appreciable lower the per cent of moisture. Thus, if the moisture content is 90 per cent, then in 100 grams of tissue there would be 90 grams of water and 10 grams of dry matter. Let us assume that 10 grams of water should be lost then there would be left 80 grams of water and 10 grams of dry matter, and the percentage of moisture would be 88.89; in other words, a loss of 10 per cent of the total weight of the tissue would change the percentage of water only 1.11 per cent. Then, in the case of the Tompkins King fruit at 12:30 P. M., where there is a reduction of the moisture content amounting to one-half of one per cent, the water loss would have been approximately 5 per cent of the weight of the tissue. These decreases with the fruit are in line with what would be expected from what was said concerning suctions in the plant. Thus, since the osmotic strength in the leaf is greater than that of the fruit, when there is incipient drying of the leaves a strong suction toward the leaves should develop and there should be a tendency for the water to move from the fruit to the leaves. However, since this water should move rather slowly there should be a small change in water percentage in the fruit during the early part of the day and the incipient drying should show earlier with the leaves than with the fruit. Since there can be but little suction toward the fruit, which has an osmotic strength no greater than that of the woody tissue, if the water is once removed from the fruit it should be very slow in again reaching its normal moisture content. The moisture content should thus remain low in the fruit long after the leaves have become fully turgid. This is in accordance with the results shown in the table. No other determinations were made from trees in sod. Several were made from trees under good cultivation, some showing slight incipient drying and some none, depending on the rate of evaporation for the day they were taken.

On September 22 fruits were detached from a Baldwin tree and tied in the tree. At four o'clock in the afternoon these fruits were taken, and with them as many fruits that had been left attached to the tree. The following statement gives the result obtained:

	Percentage	Probable error
Moisture in detached fruits (average of five determinations)	89.44	.14
Moisture in attached fruits (average of six determinations)	88.86	.08
Amount of moisture reduced by suction of water toward the leaves.....	.58	...

This shows conclusively that the fruits had lost the water by its being drawn from them toward the leaves since the detached fruits had lost very little water if any, and evaporation direct from the fruit should have been as great with them as with attached fruits.

The amount of water evaporated on July 17 from an atmometer near the Tompkins King tree from which samples were taken, was after standardizing 23.9 c.c. The total amount evaporated on September 22 when the above mentioned Baldwin samples were taken was 26.1 c.c. The average daily evaporation from July 1 to October 1 was 19.8 c.c. The total number of days during these three months with a higher evaporation than 23.9 c.c. was 32. The soil was rather dry when the Tompkins King samples were taken, but there had been abundant rain preceding the date when the Baldwin samples were taken. At the Missouri Botanical Gardens during these three months for one season the average evaporation from a standard atmometer was, according to Livingston, 26.3 c.c. Thus, in that section the average daily loss during July, August, and September, was greater than that on which we found fairly marked incipient drying of leaves and fruit of a Tompkins King tree in sod.

These results, if they are verified by numerous other determinations, would indicate that a large leaf surface may not always be favorable to the production of the largest fruits, though the leaf surface is often used as a measure of the value of certain orchard treatments. Of course, we should make it plain that we do not think the effect of large leaf surface in drawing water from the fruits at times is a determining factor so far as size of fruit is concerned. It certainly can not be except perhaps in special cases. In fact, it is not claimed that these results have large practical bearing. It is only hoped that they point out one of the many possible sources of error, or one of the many facts concerning the nature of the tree that must be recognized in planning and interpreting experiments that are expected to give practical information, and especially in correlating the results of experiments on any orchard culture problems conducted under different climatic conditions.

A PRELIMINARY CONSIDERATION OF ONE PHASE OF METEOROLOGICAL INFLUENCE ON PLANTS, INDICATED BY HAND POLLINATION OF SEVERAL COMMERCIAL VARIETIES OF APPLES.

BY W. F. FLETCHER,

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That atmospheric conditions have a marked effect on the viability of pollen and the receptability of the stigma in the fertilization of ovules of all flowering plants has long been known. What this effect is, however, or what conditions are favorable and what ones are unfavorable have in nearly all cases been merely conjecture. The old saying "An east wind blights the fruit," often heard in the northeastern fruit regions, couples the effect with one of the phenomena usually attendant on the cause. In that section of country the east wind generally is accompanied by a long, cold,

rainy spell, which, if coincident with the blossoming period of the fruit trees washes away the pollen and places a physical barrier in the way of setting fruit.

The temperature factor was studied at the Iowa State Experiment Station and the results published in bulletin No. 13, 1901. This publication states that temperatures at different times do have a bearing on the potency of pollen and the fertilization of ovules. It was demonstrated that unsacked corn pollinated at sunrise gave better results than that pollinated at any other time of day.

The rate of evaporation and humidity in the atmosphere was touched upon in a German article by M. Pfundt (*Jahrb. Wiss. Bot. [Pringsheim]*, 47 (1909), No. 1, pp. 1-40 dgm. 1). This publication treated the subject from the influence of air moisture on the duration of fertility in pollen. A summary of this article states that in no case were the pollen tubes found to withstand drying and the moisture required to preserve the vitality of pollen for any length of time varied greatly in different species, as also did the temperature at which the pollen germinated.

These factors, temperature and air moisture, influencing the set of fruit on hand-pollination of apples in the Shenandoah Valley at Gerrardstown, West Virginia, were so marked by effects as to cause a study of some of the meteorological conditions governing temperature and air moisture. For six years, 1905 to 1910, inclusive, tests were made in the same orchard, covering several commercial varieties of apples in different combinations of meteorological conditions.

The results of this work forced the author to certain conclusions. These conclusions were only accepted after being borne out consistently throughout the whole set of tests, and offer the simplest explanation of the behavior of apple blossoms under the influence of local conditions existing at the time of the work in question. The following conclusions are therefore presented to indicate a line of research which has heretofore received little careful scientific study.

1st. "The sterility or fertility of apple blossoms depends largely upon local conditions. In this statement due allowance is made for the tendencies of different varieties toward light or heavy crop setting character or productivity."

2nd. "The affinity between two varieties is governed by local conditions immediately attendant on pollination."

3rd. "Periods of rapid evaporation, that is, high temperatures, strong winds and dry air at the time of receptivity of the stigmas are detrimental to the setting of fruit."

4th. "The shock or the effect of undue exposure to the pistils previous to their natural opening or at the time of receptivity is so great and varies so much under slight changes of atmospheric conditions as to negative all comparative work in hand-manipulated cross-pollination."

In 1905 the highest per cent of fruit set was from blossoms emasculated on the morning of a comparatively cool day with light wind, and pollinated on the morning of a cool, cloudy day. The lowest per cent was from blossoms emasculated on a clear, hot day

with strong wind; and pollinated on a clear afternoon.

In 1907 the highest per cent was obtained from pollinations made during a day when the maximum temperature reached only 51°F.

In the year 1908 the Arkansas primary blossoms emasculated on April 17 when the thermometer was between 30° and 57.5°F., and pollinated by Grimes on April 22 when the thermometer was between 38.5 and 78.5°F., were the only ones that set fruit. Other pollen, except its own, was applied to the Arkansas primary blossoms during days when the maximum reached 84.5°F. or above, and they set no fruit. Of the secondary blossoms of the Arkansas the only ones to set fruit were those emasculated on April 21, when the maximum reached only 58.5°F., and pollinated by Grimes on April 27 at 2:30 P. M. When this pollinating was done the atmosphere was hazy, a light wind was blowing, the temperature was about 80°F. and the humidity was 60 per cent.

The blooming season of apples in 1909 was very cold and disagreeable for outside work and observation, yet considering the light bloom on the trees there was a heavy set of fruit which produced a good crop of apples.

The freeze of April 30, 1909, may have had a good deal to do with the results on Arkansas and Winesap. The blossoms emasculated before that date set no fruits. Of these varieties all the sets were obtained from blooms emasculated and pollinated at the same time before 9:30 A. M. on May 4.

The Grimes X Ben Davis cross handled entirely on clear days failed to set a single fruit in 1909. This is in contrast to the good results in 1905 and 1907.

In 1909, all of the Ben Davis fruits obtained from primary blossoms were on the north side of the trees, as were nearly 19 per cent of those produced by secondary blossoms. All of the latter were pollinated before 7:30 A. M. or after 5:30 P. M., and two-thirds of them set on the east and southeast sides of the trees; of these 60 per cent were pollinated after 5:30 P. M.

The weather conditions during 1910, though favorable to a fair set under natural conditions, were not so well suited to hand cross-pollination work. Rapid evaporation as indicated by wide psychrometer readings, and clear windy days, though cool, characterized the time during which the emasculation had to be done. The same conditions prevailed during the pollination period except after 3:30 P. M. on April 11 when very little wind, a cloudy sky and an occasional sprinkle of rain more than balanced the psychrometer reading of 14°F. to 17.5°F.

During the year 1910 out of one lot of 50 fruits, 19 were from blossoms pollinated while the sky was cloudy and a light sprinkle was falling, but there was very little if any wind.

In the case of single operation crosses, emasculation and pollination being done at the same time, some blossoms were handled at a comparatively high temperature while others were handled at 35°F. lower temperature, and a psychrometer reading 20°F. less.

The blossoms handled during the lower temperature set five and one-half times more fruit than those handled during the higher temperature.

The time of day factor for pollination was emphasized by the blooms cross pollinated between 10:30 A. M. and 3:30 P. M. setting 26 per cent less fruit than did the blooms cross pollinated before 10:30 A. M.

The following statement will give some idea of the effect of atmospheric conditions. Here is shown the per cent of set obtained during the six years on Grimes and the condition of the atmosphere at the time of emasculation and pollination:

Year	Per cent of set	Condition of sky at emasculation	Condition of sky at pollination
1905	12.4 +	Hazy	Hazy and cloudy
1906	3.55+	Clear	Clear
1907	19.21+	Cloudy and foggy	Partly cloudy
1908	6.14+	Clear	Clear and cloudy
1909	1.66+	Clear	Clear
1910	8.5 +	Clear	Clear

How weather conditions may affect the yield of commercial orchards is shown in the following tabulation of conditions taken from the nearest Weather Bureau Station. The yields in barrels of the same orchard in which the pollination work was done is shown. The "days above 80° F." are for the actual blooming period. The mean maximum is for the month during which the blossoming period occurred.

Year	Days above 80° F.	Mean Maximum Temperature	Yield in bbls.
		Degrees F.	
1902	8	70	379
1903	2	59	2934
1904	1	60	4287
1905	2	64	3684
1906	6	73	600
1907	2	64	2100
1908	4	68	2300
1909*	0	66	2240

*Many trees not blooming and the others with only about 50 per cent of full bloom.

Owing to the number and complication of factors entering into the fertilization of flowers and the production of fruit, these data and conclusions are in no way to be considered as final. They do, however, point to a field of investigations which is at present but little explored and a relationship between meteorological conditions and the pollination of flowers which may prove the barrier between the hybridization of species.

THE STUDY OF APPLE TREE CHARACTERS AND ITS BEARING ON VARIETY SUBSTITUTION.

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The failure of varieties to come true to name is one of the serious difficulties of the orchardist and one that seems to be on the increase. In a variety orchard recently planted at the Massachusetts college between ten and fifteen per cent of the trees planted have proven untrue to name and complaints of similar experience are received in considerable numbers every year from growers in various parts of the state.

The responsibility for these misnamed trees rests with the nurserymen and is due sometimes to deliberate deception, sometimes to gross carelessness and sometimes to the unavoidable errors of human weakness. Errors in the nursery may occur through the mixture of buds in the nursery, an error that once occurring is multiplied with the passing nursery generations, or to mistakes in labelling at the time of digging and storage or at shipment. The errors of mislabelling may be overcome by superior business organization and supervision, and this would likewise prevent bud mixtures once a pure stock was obtained. In securing and maintaining a pure stock in the nursery a more expert knowledge of tree characters would be exceedingly helpful and the discussion of this phase of the problem is the main purpose of the paper.

In the early days of pomology great attention was given to the study of varieties and at the present day almost every college making an attempt to teach the subject at all fully, offers one or more courses in systematic pomology. So far as the knowledge of the writer goes all earlier writers and the modern courses in systematic pomology lay by far the most stress on fruit characters. Reasons why this is so are obvious and yet is it not time for a more serious and adequate study of tree characters in their relation to both commercial operations and taxonomic questions. A brief study of the tree characters of apples during the past two or three years has convinced the writer that they offer almost if not quite as good opportunity for the identification of varieties as those of the fruit, and that there are many tree characters not adequately described in text books dealing with systematic pomology. The most favorable period for the observation of tree characters is probably late July, August and September. After leaf fall some of the characters of the bark and bud are more in evidence but the many characters of the leaves have been lost.

The size and vigor of the trees are of some value in the identification of nursery stock but they are, of course, greatly dependent on cultural conditions and must, like all size characters, be considered with good judgment. In young trees the form, so useful in the identification of mature trees, is not assumed, but it is indicated in some

measure by the angle formed by a branch and the main shoot. This should be observed where the main shoot is upright and the branch vigorous and free. The size of the shoots, whether stout or slender and the length of the internodes are characteristic in many varieties and should always be observed.

The color of the bark is often characteristic and by it many varieties may be quite positively known. It changes with the season being some shade of olive green during the growing season and becoming a reddish or yellowish brown with the falling of the leaves. Bark color is more easily recognized than described. The nature of the surface of the bark, whether smooth, rough, shining or dull and the amount and nature of a scurf skin and, during the growing season the abundance and nature of the pubescence on young shoots will be found useful.

Among the characters of the bark about the most dependable are the lenticels. These are in some varieties very abundant and in others very scattering; they vary much in size but this seems to be somewhat subject to environmental conditions. In some varieties they seem to be distinctly raised above the surface while in others they are even with it. This distinction, though slight seems to be remarkably constant.

The color of the wood sometimes differs with the variety, also its flexibility, some varieties being stiff and easily broken, others notably willowy, bending much before breaking.

The size and form of the lateral buds will be found to be of frequent significance, also their position, whether clinging closely to the shoot or standing free from it.

Although the individual root systems of nursery trees are of seedling growth and therefore differ every one from its neighbor, they are so controlled by the growing bud that each assumes a form more or less characteristic of the variety. In many cases the nurseryman recognizes positively the variety by the form of the root system.

All these characters are available whether or not the tree is in an active condition but most of them are most clearly seen when the tree is dormant, they are therefore especially valuable in the identification of nursery stock. Any one thoroughly familiar with the dormant tree should be able to recognize the leading varieties or at any rate to tell if a given lot of trees is of the variety stated, a problem that is much simpler than to correctly identify an unknown variety.

When the trees are in an active growing condition we have the added characters of the leaves which in our experience are even more valuable than those of the dormant tree in the identification of varieties. In fact it is possible to identify many varieties of apples with reasonable certainty from the characters of the leaf blades alone if the trees are young and in a fairly vigorous growing condition.

The length and size of the petiole and during the latter part of the growing season the amount of color thereon are often characteristic. The size and form of the stipules will often be found useful.

The many characters of the leaf blade are extremely helpful and some of those that we have found especially valuable do not seem to be generally very clearly recognized. The size of the blade is of course largely dependent on the vigor of the tree but one may usually make due allowance for this. Rhode Island Greening and Fallawater leaves will always be relatively large and Jonathan and Hubbardston leaves relatively small. In some varieties such as Wealthy and McMahon the leaves are flat while in Jonathan, Wagener and Grimes they are strongly folded upward. Other varieties are intermediate and in Baldwin and Yellow Transparent the folding is of a peculiar character not easily described but readily recognized when once known. In either folded or flat leaves the two sides may be even or they may be more or less waved or wrinkled. Jonathan, Northern Spy and Tompkins King are waved while Maiden Blush, Winesap and Baldwin leaves are even. In wrinkled leaves the undulations are finer than in waved ones. Varieties that approach this leaf condition are Red Astrachan and Wolf River. In any such leaves as these the midrib may be straight or it may be curved backward and downward in which case the leaf may be said to be reflexed. Occasionally, as in Rhode Island Greening and Stark there is a tendency for the leaf to be reversely curved. Examples of varieties having straight midribs are Oldenburg, Fallawater, Winesap and Grimes while in Hubbardston, Sweet Bough, Wagener and Red June the midrib is reflexed.

The various possible combinations of these characters give peculiarities enabling one to quite positively recognize a great many varieties, in Massachusetts at least. How constant they may be the country over we are at present unable to say though we feel quite confident that they are not confined to one section. It should be added that these characters are best observed from midsummer on.

A few varieties characterized by the following types of leaves may be mentioned:

Baldwin—folded, even and straight or slightly reflexed.

Ben Davis—folded, somewhat waved and sometimes reflexed.

Northern Spy—partly folded, waved and slightly reflexed.

Jonathan—folded, waved and sometimes reflexed.

Yellow Newtown—folded, nearly even and reflexed.

Winesap—sometimes partly folded, even and straight.

Rhode Island Greening—nearly flat, almost even and straight or reverse curved.

Oldenburg—nearly flat, slightly waved and straight.

The outline of apple leaves generally approaches oval, but in many varieties it varies toward ovate, roundish or oblong, with varying width of the base and apex. Sometimes the leaves form a narrow angle with the shoot and may be said to be erect while in others they form a wider angle and may be said to be spreading. Examples of the former are Northern Spy, Pewaukee and Wagener, and of the latter, Oldenburg, Rhode Island Greening and Wealthy.

This character is probably correlated with that of the angle of the branches to which reference has been made.

A close study of the leaf edges or serratures will afford a basis for the partial or complete identification of many varieties. Some are sharply serrate, others dull serrate or even crenate while some approach a dentate form. Examples of sharply serrate leaves may be found in Rhode Island Greening, Chenango and Fall Pippin; the Maiden Blush, Arkansas and Sutton are a duller serrate while Milwaukee, Peck Pleasant and McIntosh are almost or quite crenate. The size of the serratures varies with the size of the leaves but taking this into consideration, it offers aid in identifying varieties. The serratures of Porter, Fall Pippin and Wagener are large while those of Walbridge, Williams and Maiden Blush are relatively small. Sometimes as in Baldwin the individual serratures are curved forward while in others as Dominie they are straight. The depth and width of the spaces between the serratures differ. They are deep in Fall Pippin and shallow in Primate, McIntosh and Gano; wide in Rhode Island Greening and narrow in Baldwin. In some varieties the serratures are fairly regular, in others irregular and in some there is a tendency to doubleness. The thickness and stiffness of the leaves vary much as does also the texture of the surface. In some varieties the distribution of the veinlets gives a coarse texture, in others it is a fine texture. There is also much significance in the amount and nature of the pubescence on the under surface of the leaves and in their color, this varying from a bluish or grayish green to a light or yellowish green. The latter may of course be much modified by the health and vigor of the tree.

The foregoing is a brief survey of some of the tree characters of apples that are of value in identifying varieties. There are many others of lesser or possibly equal value. Probably the study of other groups of fruit would reveal equally good opportunity for the identification of varieties. An amount of study equal to that usually given to fruit in a thorough course of systematic pomology ought to train students to recognize varieties by tree characters as positively as they now do by fruit characters. If in addition to this training they become fairly familiar with general nursery practice, so that they may be of use to the nurseryman throughout the year, they will doubtless find ready employment in nursery work with good prospects for future advancement. They may thus be in a position to do much to lessen the vexation arising from variety mixtures.

The solution of the problem of variety mixtures must lie in the hands of the nurseryman. No one else is in a position to bring about the day when variety mixtures shall be no more. It is our belief that most nurserymen are ready to do what they can to hasten the time though perhaps they do not feel the problem so acutely as the orchardist who has experienced the disappointment of planting McIntosh and picking Ben Davis. Is not the problem worthy of study and cooperative effort on the part of the horticultural investigator and teacher?

The following descriptions are intended to apply to trees from the age of two to five or six years as they appear during late summer or early fall:

Baldwin. Tree large, upright, spreading, moderately dense, vigorous; shoots, medium length, medium to stout, not curved, somewhat diverging; internodes medium; bark yellowish olive, smooth and shining, medium thick with little pubescence; lenticels medium in number, size medium or above, generally oval, brownish gray, raised; wood rather soft, quite flexible; buds medium size, broad, roundish, nearly free, somewhat pubescent; leaf petiole medium length, considerably tinged with red; leaf blade medium or above in size, folded, even, straight or slightly reflexed, broad oval, nearly erect, base rounded or rather broad, apex broad to very broad; serratures rather sharply serrate, strongly forward, often curved, medium size, rather deep and fairly irregular, close set, texture smooth and fine, pubescence little, short.

Ben Davis. Tree above medium to large, upright-spreading, drooping with age, quite dense, vigorous; shoots medium long, rather slender, diverging, slightly curved, internodes short; bark medium, reddish olive, medium thick, somewhat pubescent; lenticels very few, medium size, roundish, brownish gray, raised; wood hard and flexible; buds medium size, broad-obtuse, appressed; leaf petiole long, medium size, well tinged; leaf blade small, folded, somewhat waved, sometimes reflexed, narrow oval, spreading; base narrow to very narrow, apex generally medium, rather thin, serratures dull serrate or crenate, moderately forward, somewhat curved, slightly shallow and quite irregular, texture fine, smooth, pubescence much, wooly.

Gano. Tree medium size, roundish, spreading, drooping with age, moderately dense, vigorous; shoots medium length, rather slender, diverging, spread or slightly curved with long internodes; bark medium yellowish olive, rather thin; lenticels few, medium or small, roundish, rather dark gray, raised; wood medium hard, rather stiff; buds small, obtuse and appressed; leaf petiole long, slender, considerably tinged; leaf blade small, somewhat folded, sometimes waved, straight or slightly reflexed, narrow, oval, spreading; base generally narrow, apex narrow, serratures crenate, forward, medium deep to very shallow, not curved, fairly regular, texture medium, smooth, pubescence medium, wooly.

Grimes. Tree medium size, roundish, spreading, moderately dense, quite vigorous; shoots medium length, medium to slender, ascending or erect, internodes medium; bark dark olive green, dull, rather thick; lenticels many, small to medium, roundish, medium gray, nearly even; wood quite hard and quite flexible; buds small to medium, obtuse to acute, partly free; leaf blade medium or below in size, strongly folded, waved, nearly straight, medium or narrow, oval inclining to ovate, erect; base narrow, apex medium to narrow, serratures distinctly serrate, well forward, medium or above in size, moderately deep, rarely slightly curved, irregular, texture medium, pubescence little, short.

Jonathan. Tree large when young, spreading, open, moderately vigorous; shoots rather short, very slender, spreading, nearly straight; internodes medium; bark clear yellowish olive, thin; lenticels medium or below in number, medium size, roundish, medium gray, slightly raised; wood soft and flexible; buds medium size, rounded, free; leaf petiole short, rather slender, well tinged with pinkish red; leaf blade very small, folded, waved, sometimes reflexed, oval, rather spreading, base narrow, apex medium, serratures generally dull serrate, rather indistinct, and generally well forward, medium or rather small, shallow, often curved, irregular, texture rather coarse, pubescence medium, short.

Maiden Blush. Tree above medium in size, upright, roundish, moderately dense, vigorous; shoots long, rather slender, slightly curved; internodes very short; bark medium greenish olive, rather dull and smooth, thick; lenticels medium or above in number, medium size, roundish, medium gray, even or very slightly raised; wood hard and rather flexible; buds medium size, medium-obtuse; free; leaf petiole medium or below in length, stout, tinged at base; leaf blade rather small, partly folded, even, more or less reflexed, medium oval to ovate, nearly erect, base rather broad, apex medium to narrow, serratures dull serrate, moderately forward, moderately deep, not curved, small, irregular with strong tendency to be double, texture rather coarse, pubescence little, wooly.

McIntosh. Tree above medium to large, roundish, spreading, not dense, vigorous; shoots medium or long, medium size, somewhat curved, internodes medium or rather short; bark medium greenish olive becoming reddish on sunny side in late summer, rather thin; lenticels very many, medium size, generally roundish, brownish gray, distinctly raised; wood medium hard, quite flexible; buds medium or below in size, obtuse, nearly free; leaf petiole rather short, medium or rather stout, well tinged toward the base; leaf blade medium or above in size, partly folded, even, somewhat reflexed, broad oval sometimes approaching ovate, spreading, base rather broad, apex medium, serratures distinctly crenate, shallow, medium or below in size, fairly regular, texture rather coarse, pubescence heavy, wooly.

Northern Spy. Tree medium in size, upright, quite dense, moderately vigorous; shoots long, medium size or rather slender, ascending, slightly curved, internodes short to long; bark medium greenish olive, rather dull, rather thin; lenticels medium in number, small to medium in size, roundish, medium gray, raised; wood rather hard and stiff; buds small, obtuse, appressed; leaf petiole generally long, medium size, well tinged in late summer; leaf blade medium or below in size, partly folded, waved, slightly reflexed, rather broad oval tending to ovate, erect, base rounded, apex medium to slightly narrow, serratures medium serrate, well forward, medium or below in size, rather shallow sometimes slightly curved, fairly regular, texture medium, pubescence little and fine.

Oldenburg. Tree rather small, upright, spreading, open, only moderately vigorous; shoots medium to long, medium size, nearly

straight, internodes medium; bark dark reddish olive, rather dull, medium thick with little pubescence; lenticels medium or above in number, medium to large, roundish to elongated, light gray, slightly raised; wood quite hard, medium flexible; buds medium to large, roundish acute, free; leaf petiole long, medium size, considerably tinged; leaf blade rather large, nearly flat, slightly waved and straight, broad oval, spreading, base broad, apex broad to very broad, serratures dull serrate, medium size, medium depth, slightly curved, irregular, texture medium, pubescence medium in amount, short.

Red Astrachan. Size, medium, form roundish, upright, moderately dense, vigorous; shoots medium to rather long, medium size, nearly straight, ascending, internodes medium; bark medium greenish olive, smooth, dull, thin with little pubescence; lenticels very few, medium size, roundish, medium gray, even; wood medium hard, rather stiff; buds medium to large, acute, free; leaf petiole medium length, medium size, somewhat tinged in late summer; leaf blade rather large, somewhat folded, waved or wrinkled, straight, oval, spreading; base rounded, apex rather broad, serratures dull serrate, medium size, medium depth, slightly curved, moderately regular, texture medium, pubescence medium in amount, short.

Rome Beauty. Tree medium size, upright, medium density, quite vigorous; shoots rather long, medium size, straight, ascending, internodes medium; bark clear light greenish olive, smooth, partially covered with scarf skin, rather thick; lenticels few, medium or above in size, roundish, medium gray, nearly even; wood rather hard, moderately stiff; buds medium size, short, obtuse, appressed to partly free; leaf petiole medium length, medium to rather stout, often considerably tinged; leaf blade very large, nearly flat, almost even, straight, narrow to medium, oval tending toward ovate, very thin, erect or drooping in case of large leaves, base rounded, apex medium, serratures medium serrate, rather small, moderately deep, well forward, not curved, fairly regular, texture smooth, pubescence little and short.

Wealthy. Tree medium size, irregular, spreading, open, only moderately vigorous; shoots medium length, rather slender, spreading or irregular, curved, internodes medium or below; bark dark reddish-green olive, rather dull, thin; lenticels medium in number, medium to rather large, generally roundish, light gray, nearly even; wood quite hard, quite flexible; buds medium size, broad-obtuse, appressed; leaf petiole medium or above in length, medium size, tinged about base; leaf blade medium or below in size, slightly folded, waved, slightly reflexed, oval, spreading, base rounded, apex medium, serratures almost crenate, rather small, not curved, medium regular, texture medium, finely pubescent.

Wincap. Tree above medium to large, roundish, spreading, moderately dense, vigorous; shoots medium length, slender, spreading or ascending, curved, internodes generally short; bark dark greenish olive, dull, smooth with heavy gray scarf skin; lenticels few, small to medium, roundish, brownish gray, even; wood hard.

flexible; buds prominent, medium to large, medium to acute, nearly free; leaf petiole medium length, slender, well tinged at base; leaf blade small to medium, sometimes partly folded, even, straight, medium to broad, oval, spreading, base rounded, apex medium to broad, serratures very dull serrate or crenate, well forward, often curved, rather large, shallow, texture coarse, pubescence little, short and fine.

Yellow Bellflower. Tree large, roundish, drooping, quite dense, vigorous; shoots long, medium size, ascending or irregular, curved, internodes medium; bark greenish olive, smooth, dull with thin gray scarf skin; lenticels medium in number, medium to large, roundish, medium gray, even; wood rather hard, quite flexible; buds prominent, large, medium to acute, free; leaf petiole medium length, rather slender, somewhat tinged; leaf blade medium or above in size, sometimes partly folded, even, often more or less reflexed, narrow, oval, spreading, base narrow, apex medium to narrow, serratures medium serrate, quite distinct, medium or above in size, medium depth, very slightly curved, irregular, texture rather coarse, pubescence short, rather fine.

FURTHER RESULTS WITH DYNAMITE FOR TREE PLANTING.

By A. J. FARLEY, *Experiment Station, New Brunswick, N. J.*

Experiments to determine the value of dynamite for tree planting were started by the New Jersey Experiment Station at Vineland and New Brunswick, in the spring of 1912. These tests were originally designed to study the effect of dynamite in connection with the planting of apple and peach trees, but pear trees were also included in additional experiments started in 1913. A report, giving a general outline of each experiment including varieties, method of planting, types and condition of soil, together with observations made during 1912 and 1913, was presented at the annual meeting of this society last winter. The varieties of peaches included in the Vineland and New Brunswick tests are Carman, Stump and Elberta, while the experiment with apples at New Brunswick includes the varieties Wealthy and Delicious. Each experiment includes rows of trees planted in holes made by exploding one-half a stick of 20 per cent dynamite at a depth of 18 inches, while check trees were set in furrows made of good width and depth by going across the field and back, plowing twice in each furrow.

The Vineland experiment is being conducted upon a gravelly, medium sandy, loam soil with a sub-soil containing some clay. The New Brunswick experiment with peaches is being conducted upon a fairly deep, dense red shale loam containing some coarse gravel, while the experiments with apples and pears are located on a rather heavy clay loam soil with a stiff clay sub-soil.

The circumference of each trunk and the lineal twig growth made by each tree included in the various experiments has been carefully measured each year with the following results.

In the Vineland experiment a comparison of 124 trees is being made, 62 of which were planted in holes blown out with dynamite, while an equal number were planted in the usual manner. At the end of the first season careful measurements of the lineal growth of the branches and twigs of each tree revealed the fact that the average total lineal growth of the dynamited trees was 794 inches, while that of the trees planted in the ordinary way was 655 inches, a difference of 139 inches of lineal twig growth per tree in favor of dynamiting. The average lineal branch and twig growth of the dynamited trees made during the second season was found to be 4,651.6 inches per tree compared to 3,303.8 inches per tree made during the same period by the trees planted without the use of dynamite. These measurements for the second season show a difference of 1,347.8 inches in favor of the trees planted in holes blown by dynamite. The lineal twig growth for the third season has been measured, but the measurements could not be tabulated in time to be incorporated in this report.

Measurements of the circumference of the trunks of these trees taken at the end of the first season, showed an average difference of .22 inches per tree in favor of the trees planted without the use of dynamite. The dynamited trees had decreased this difference to .02 inches per tree at the end of the second season, while at the end of the third season the average trunk circumference of the dynamited trees was .17 inches greater per tree than the average trunk circumference of the trees planted without dynamite. These results indicate that in three years the dynamited trees have made an average net gain in trunk circumference of .39 inches per tree and in two years an average net gain in lineal twig and branch growth of 1,347.8 inches per tree on the trees planted in the usual manner.

The trees in this experiment produced their first crop of fruit the third season with the following results.

Our records show that Carman is the only variety that produced a heavier crop on dynamited than on undynamited trees. The total yield of this variety was 100 pounds and 4 ounces greater from the dynamited trees, than from those undynamited, while the average yield per tree was 7 pounds and 11 ounces in favor of dynamiting. The other varieties, Stump and Elberta, show a slight difference in yield in favor of the trees planted without the use of dynamite. However, the total yield from both of the latter varieties was so small that comparisons are of doubtful value.

The experiments with peaches at New Brunswick include 72 trees on which measurements have been made in the same way as at Vineland. At the end of the first season the average amount of branch and twig growth per tree in favor of dynamiting was found to be 137 inches, while the average difference in the circumference of the trunks was .24 inches. The average lineal branch and twig growth made by these trees the second season was 157 inches per tree in favor of dynamiting, while the average difference in trunk circumference was reduced to .18 inches per tree. The measurements made at the end of the third season show an average difference of 53

inches per tree in favor of the trees not dynamited, while the average difference in trunk circumference is .01 of an inch in favor of the same trees. These measurements indicate that the difference in lineal growth and trunk circumference in favor of the dynamited trees at the close of the first season has not only been reduced to zero, but the trees not dynamited are at present actually larger than the trees planted in the dynamited rows. The Carman trees in this experiment also produced their first crop the third season with the following results. The average number of fruits per tree on the undynamited block was 85 having an average weight of 15 pounds and 11 ounces. The average number of fruits per tree on the dynamited block was 135 having an average weight of 21 pounds and 13 ounces. The above figures show that the dynamited trees yielded 50 fruits more per tree than the undynamited trees and that the difference in weight was 6 pounds, 2 ounces per tree in favor of the dynamited trees, however, this difference in yield is so small that it does not entirely substantiate the claim made by manufacturers and other interested parties, that trees planted in dynamited holes will come into bearing one or two years earlier and produce more fruit of better quality and higher color than trees planted in the usual manner. Careful measurements of the apple trees in the New Brunswick experiment show but a slight difference between the trees planted with dynamite and those planted in the ordinary way. At the close of the first season the average lineal twig growth made by the Wealthy trees was but 1.4 inches and the average trunk circumference .07 of an inch per tree in favor of dynamiting. The Delicious trees, during the same period made an average lineal twig growth of 12.1 inches and an average trunk circumference of .18 inches in favor of dynamiting. At the close of the second season the Wealthy trees showed a difference of .09 of an inch per tree in average trunk circumference in favor of dynamiting, while the average lineal twig growth at the same time was 80 inches per tree in favor of the trees planted without the use of dynamite. Measurements made of the Delicious trees at the close of the second season show that the dynamited trees have an advantage of .13 inches in average trunk circumference and 193 inches in average lineal twig growth over the trees planted in the usual manner.

Measurements of the pear trees in the New Brunswick experiment show, in most cases, some difference in favor of dynamiting both in trunk circumference and lineal twig growth. The trees in this experiment were planted in the spring of 1913, one year later than the apple and peach trees at Vineland and New Brunswick. The soil is a heavy clay loam with a stiff clay sub-soil. Measurements of the lineal twig growth were not made at the close of the first season, but after the trees had completed their second year's growth it was found that the dynamited trees had made an average lineal twig growth of 289.6 inches per tree compared with 221.9 inches per tree made by the trees that were not dynamited. The above measurements show an average difference of 67.7 inches of lineal growth in favor of dynamiting.

The trunk circumferences of these trees were measured at the close of the first season and again at the close of the second season with the following results. The average difference in favor of dynamiting at the end of the first season was .12 inches and at the end of the second season .15 inches.

The results of dynamiting for tree planting based upon the tests made at the New Jersey Station during the past three years may be briefly summarized as follows:

Peach trees planted at Vineland by the use of dynamite have shown a noticeable advantage in the amount of branch and twig development over trees set in the usual manner.

With the exception of the first season this advantage in twig and branch growth has been accompanied by a corresponding advantage in the circumference of the trunks.

The advantage in branch and trunk development established by the dynamited peach trees at New Brunswick during the first season has not been maintained during the second and third seasons, but on the contrary has been reduced to such an extent that the advantage is now in favor of the undynamited trees.

The crop of peaches produced by the New Brunswick and Vineland trees during the third summer show a noticeable advantage in favor of dynamiting in the case of the variety Carman, the only variety which produced what could be termed a profitable crop.

The increased crop of Carman produced by the dynamited trees the third season was worth more than enough to pay for the cost of the dynamite used for planting. This above statement does not hold true in the case of the varieties Stump and Elberta.

The difference in twig and trunk circumference has not been so great with apple trees as it has with peach trees.

Pear trees planted with dynamite show, after two years' growth, a slight advantage, in both twig growth and trunk circumference, on the trees planted in the usual manner.

Trees planted with dynamite have developed a deeper root system than trees planted by ordinary methods.

The cost of planting trees with dynamite under the conditions existing at Vineland and New Brunswick is from 4 to 5 cents per tree greater than the cost of ordinary planting.

The results of our experiments indicate that in the majority of cases the increased growth and fruit production recorded on dynamited trees is not great enough to make up for the increased cost and danger involved in planting. Furthermore the use of dynamite is not recommended for tree planting on those soils that are naturally adapted to orcharding.

FACTORS CORRELATED WITH HARDINESS IN THE APPLE.

By F. W. ALLEN, *Washington State College, Pullman, Wash.*

The breeding of hardy varieties of apples adapted to growing in the northern states and Canada is an important line of work which has been carried on for more than a quarter of a century. Al-

though much has been accomplished in this time, the work is of such a character that results are necessarily very slow. Time and patience are necessary in any line of plant breeding and particularly is this true when testing the hardiness of tree fruits. The general method for determining this has been to wait for several years, or in some cases much longer, to see how well the tree might be adapted to growing under the existing conditions. This necessity is a great drawback to the breeder. It is well known, in the case of seedling trees that those showing a very thorny character of twig will never prove of any value, hence these trees can be discarded at once, thus saving much time and allowing the ground to be occupied with others of more promise. If thorniness is a characteristic by which one is able to predict the value of a tree, or its fruit, might there not be some characteristic or some test that could be applied which would indicate its relative hardiness?

Varieties will of course differ in their ability to withstand cold, depending upon the age of the trees and the conditions under which they are growing, so that to make any test of real value it should be on a comparative basis. The writer made tests of twigs representing varieties from several sections of the United States as well as from Canada and Alaska, but secured the best results from trees growing in a small nursery planted for this particular purpose on the Iowa Experiment Station grounds. About thirty-three varieties were tested including.

Anisim	Grimes	P. Fusca
Baltimore	Hibernal	Red June
Brilliant	Ingram	Roman Stem
Ben Davis	Iowa Blush	Salome
Black Annette	Jonathan	Silkenleaf
Brier Sweet	Lansingburg	Soulard
Charlamoff	McIntosh	Stayman Winesap
Delicious	Minkler	Virginia Crab
Dudley	Oldenburg	Walbridge
Gano	Patten	Wealthy
Green Sweet	P. Ioensis	Winesap

This list was considered sufficient for a comparison of the very hardy and more tender varieties and as all the trees were grown under the same conditions many factors of probable error attending the scions secured from other sources were eliminated.

THE FACTOR OF MATURITY AND WATER CONTENT.

It is well recognized that the maturity of the tree at the beginning of cold weather bears a very important relation to its ability to withstand cold. Active growing plants contain relatively large amounts of water causing the cell sap to freeze at a high temperature. Mature plants on the other hand contain a more concentrated cell sap which has a lower freezing point. When a tree is injured by cold the twigs are generally the first part to suffer. The new growth contains the most sap-wood and consequently the most

water. The age of the tree and the system of management under which it has been growing are very important factors which the orchardist generally recognizes. Aside from these, however, there is a constitutional difference between different varieties, and perhaps even different trees of the same variety. Some varieties naturally take a longer time to mature their wood. One of the first points noted with the trees named above was the time at which the terminal buds formed. Below are just a few of the hardy and more tender varieties given for comparison:

VERY HARDY VARIETIES.

Anisim	terminal buds formed	Sept. 1
McIntosh	“ “ “	Aug. 28
Oldenburg	“ “ “	Aug. 20
Hibernal	“ “ “	July 25
Soulard	“ “ “	Aug. 20
Virginia Crab.....	“ “ “	Aug. 20
Wealthy	“ “ “	Aug. 20
Silkenleaf	“ “ “	Sept. 1

MORE TENDER VARIETIES.

Ben Davis.....	terminal buds formed	Sept. 27
Gano	“ “ “	Sept. 27
Grimes.....	grew until frost	
Winesap	terminal buds formed	Sept. 5
Jonathan	“ “ “	Sept. 27
Iowa Blush.....	grew until frost	
Delicious.....	“ “ “	

These figures seem to show pretty conclusively that the hardest varieties mature their wood from a few days to several weeks ahead of the less hardy sorts. Other figures at hand taken from older trees show practically the same results. All of the above trees grew considerably later than the same varieties of bearing age as would naturally be expected. In selecting trees for very severe regions, however, only those which cease their growth early in the season should be chosen. In the above list the Hibernal stands out pre-eminently as an early maturing variety, forming its terminal buds two months before Jonathan and nearly three months before some of the other varieties which were killed by frost. While Hibernal may not be the hardest variety in the list, it is certainly one of the most hardy sorts and its early maturity is considered a very important factor.

As loss of water might be considered the most important change which takes place during the ripening of the wood, one is led to ask, "Do the hardy varieties contain, or carry on their life functions with, a smaller amount of water than do the less hardy varieties?" Some investigations were carried on to determine if this might be true. The results obtained showed the hardier varieties as a rule to contain several per cent less water in their wood during the growing season. As the season advanced and the weather became cooler this margin of difference grew less, and on January 15

after a week of weather ranging from zero to 15 degrees below the hardier varieties were found to contain from two to four per cent more water than the tenderer varieties. Comparing Hiberna and Wealthy with Grimes and Delicious in this respect the results were:

	July 15	Jan. 15
Hiberna	53.5 per cent	46.8 per cent
Wealthy	56.5 " "	47.0 " "
Grimes	60.7 " "	43.6 " "
Delicious	60.3 " "	42.5 " "

These figures indicate that not only do the hardier varieties function with a smaller amount of water in their tissues, but that during a spell of very severe weather they retain their more concentrated cell sap and are not dried out so readily by the continued cold. Nearly two hundred tests were made in duplicate to determine the rate of evaporation from the different varieties. The results were very interesting, showing in almost every case that the hardier varieties retained their moisture for a longer period, thus being one factor at least in enabling the so-called hardy varieties to withstand long, cold winters. The freezing point of the cell sap (determined by density or water content of twig) and the rate of transpiration at a time when the roots are encased in frozen soil, are certainly important factors regarding hardiness. By taking notes on maturity and making tests to determine the rate of transpiration and the freezing point of the cell sap, the writer believes that a pretty accurate idea of the tree's hardiness can be obtained.

STRUCTURE AND COMPOSITION OF THE WOOD.

If there is a difference in the rate of evaporation between the hardy and tender varieties what is the reason for such difference and is it due in any measurable extent to structural characters or physical composition that can be measured or accurately determined? It would be natural to suppose that the thickness or structure of the bark would be a determining factor. Both longitudinal and cross sections of twigs of the various varieties were made and studied to determine the size of the pith, thickness of bark, shape and arrangement of cells in the cutinized layers, shape, size, arrangement and number of rows of the collenchyma cells, the amount of stored food and the per cent of wood lignified. These last two factors being very closely correlated with maturity were studied in that connection. The results obtained are entirely too long to give in detail. Suffice it to say that while there seems to be some correlation between the thickness and structure of the bark with the rate of evaporation, yet the figures obtained from a large number of examinations are not conclusive. In most cases the hardier varieties had a little thicker bark than the more tender sorts, yet the minimum thickness of bark of the former was often exceeded by the maximum thickness of that on the tenderer varieties so that there is an overlapping which makes it difficult to make any positive

statements in this regard. The results show that the amount of stored food contained in the twig bears some relation to hardiness. Grimes and *P. Ioensis*, however, seem to be exceptions since the former variety was found to have the pith cells well filled with starch, whereas the latter contained about the least amount of any variety studied. In all probability the thickness and shape of the cells comprising the cutinized layers are a factor which functions here, as well as the number of layers and entire thickness of the bark. To determine this, however, would be extremely difficult.

THE BLOSSOMS CORRELATED WITH HARDINESS.

The size of the various parts of the blossom as being an index to the hardiness received some attention about twenty-five years ago from Halsted.* The conclusions drawn were that the blossoms of the hardier varieties had larger, thicker petals; shorter and more stocky pistils and stamens and larger stigmas, anthers and pollen grains. A brief study was made of these characteristics in twenty-two varieties, including some of the most hardy and tender sorts and it was found in the main that the hardier varieties did have the larger, but not always the thicker petals. Such varieties as Oldenburg, Patten, Wealthy and Charlamoff, had much larger petals than Jonathan and Ben Davis. Regarding the length of the pistil and the stamens, the results obtained were largely contradictory to those of Halsted. Oldenburg, Patten, Hibernial, Walbridge and *P. Ioensis*, have the longest pistils and stamens of any of the varieties noted, being from one-fourth to one-third longer than those of Ben Davis, Gano and Winesap. Brilliant, which is generally classed as being quite hardy, had the shortest pistils and stamens of any variety measured. Those of the McIntosh variety were also short. Ben Davis, Gano, Grimes and Jonathan ran medium in length. No measurements were taken to determine the exact thickness of the petals, but this point could be determined quite accurately by carefully feeling one variety after another. A distinct difference could be noted by this simple method, the varieties being classified as follows:

Petals Thick	Petals Medium Thick	Petals Medium Thin	Petals Thin
Anisim	Ben Davis	Charlamoff	Black Annette
Hibernial	Brier Crab	Grimes	Gano
<i>P. Ioensis</i>	Brilliant		Green Sweet
Oldenburg	Dudley		Roman Stem
Patten	Jonathan		Walbridge
	McIntosh		Winesap
	Red June		
	Soulard		
	Wealthy		

All five of the varieties having thick petals are very hardy and all have large petals with the exception of the *P. Ioensis*. Brilliant

*Ia. Exp. Sta. Bul. 3, 1888.

is another hardy variety having a moderately thick but small petal. Charlamoff which is a hardy variety has large but thin petals so that the thickness of the petal is not necessarily correlated with size although this is the general rule. While the examination of the above varieties is scarcely sufficient to conclude that large size and thickness of petals are unmistakable characteristics of hardiness yet it is significant that none of the varieties possessing these characteristics are tender. The large size of the petals appears to be a characteristic of the Russian sorts and while these are hardy varieties yet they are probably no harder than the native crab (*P. Ioensis*) and several other varieties with smaller petals.

DENSITY OF WOOD A PROBABLE FACTOR.

It is a fact of common observation to the orchardist when pruning that some varieties of trees are much more resistant to the knife or saw than others. The *P. Ioensis* crab has a much harder wood than a cultivated variety such as the Ben Davis. The former also makes a much slower growth and is hardier. Thus in this case at least, the texture of the wood is correlated with the ability of the tree to withstand cold. Mechanical tests are of great value in testing the hardness and strength of large timbers, but so far as is known no such tests have ever been made with small scion wood with the idea of correlating their hardness with hardiness. As most of the wood tested did not run over four millimeters in diameter it was necessary to contrive a small machine for such work. Cutting, penetration and compression tests were made using fresh and dry wood of the hardy and tender varieties. Each variety went by number instead of by name and the tests were made with scions four millimeters in diameter at a point half way between tip and base. This point was selected arbitrarily in order to make all the tests comparable. The scion wood used was taken from the Iowa Experiment Station nursery, and from various sources over the United States, Canada and Alaska. The figures given below are averages from a number of samples and show something of the results obtained:

Test	Variety	Pounds Pressure
Cutting (green wood)	Delicious	45.6
“ “ “	Jonathan	36.7
“ (dry wood)	Delicious	57.5
“ “ “	Jonathan	43.9
“ (green wood)	Stayman Winesap	53.4
“ “ “	Winesap	23.8
“ (dry wood)	Stayman Winesap	71.9
“ “ “	Winesap	30.8
Compression (green wood)	Stayman Winesap	82.2
“ “ “	Winesap	55.5
“ (dry wood)	Stayman Winesap	155.7
“ “ “	Winesap	.....

The Delicious which is advertised by its chief propagators as being slightly harder than the Jonathan proves to have the harder

wood. The Stayman Winesap has wood almost twice as hard as Winesap. It produces larger fruit and seems better adapted to growing under northern climatic conditions. These two examples would indicate that hard wood is correlated with hardness. Some other varieties show similar results but many are quite variable making definite conclusions impossible. From the general trend of results, however, obtained from nearly two thousand individual tests, the speaker is led to believe that there is some correlation between these two factors.

In order to test this question from another standpoint, specific gravity tests were made and compared with the mechanical tests. In this work it was decided to use only dry wood and weigh it in some liquid which the twigs would not readily absorb. Castor oil was finally decided upon. Weighing in oil instead of water involved the work to some extent as the results had to be figured for both oil and water thus making the tables very long. The results in general indicated a very close correlation between specific gravity and the hardness of the wood. Hence the two tests are a fairly accurate means to the same end. In correlating density with hardness, however, the results show nothing more than those obtained by the mechanical tests. Variations in specific gravity of the same variety from different sources were quite noticeable. The same variety from the same source gave pretty uniform results. In this test as in the one above, a certain section of the twig had to be used in each case as the results varied quite materially when different portions of the scion were used. The more tender varieties which mature their wood a little later in the summer gave the greatest specific gravity a short distance back of the tip, while earlier maturing varieties increased in specific gravity in proportion to the distance from the tip. As the tests were made in July this difference is in all probability due to the relative maturity of the twig.

FREEZING TESTS.

Freezing tests were conducted to determine, if possible, the temperature at which the various varieties would be injured under a given condition, and also to determine the relation between the moisture content and the ability of the twig to withstand cold. Twigs were cut during the middle of January, immediately brought to the laboratory and subjected to various degrees of low temperatures. A special freezing box was devised suitable for the work. The temperature was lowered gradually at first using salt and ice and then reducing the temperature lower with liquid carbon-dioxide. In this way a very low temperature could be obtained, but unfortunately with the equipment at hand, it was impossible to hold it stationary for any length of time, and hence the exact point at which the various varieties were killed could not be ascertained. After freezing, the twigs were allowed to remain in the box surrounded with salt and ice until thawed. The basal ends were then clipped off and the scions placed in water to be forced into growth.

All twigs were found to be either killed or seriously injured when suddenly subjected to a very low temperature even though it was for a very short time. A longer period of moderate cold slightly injured the hardier varieties and killed most of the tender ones. A few of the tests were as follows:

Set I. Hibernial, Oldenburg, Wealthy, Gano, Grimes, Winesap. Twigs precooled and frozen for 45 minutes at -30° to -50° F. All twigs killed.

Set II. Varieties same as above. Frozen 1 hour and 45 minutes at -30° to -58° F. The temperature was held between -30° and -40° F. most of the time. All twigs killed with the exception of the Hibernial.

Set III. Varieties same as Set I. Frozen for 30 minutes at from -30° to -40° F. Tips of Oldenburg and Hibernial killed back two inches. All other twigs dead.

Set IV. Varieties same as Set I. Frozen 30 minutes. Temperature -15° to -40° F. Wealthy and Hibernial injured one inch at the tip. All other varieties injured two and one-half inches and more.

Set V. Varieties same as Set I. Frozen for 20 minutes. Temperature -10° to -15° F. Hibernial and Oldenburg killed back one-half inch from the tips. Wealthy killed back one inch. Gano, Grimes and Winesap killed back two inches and more.

Set VI. Grimes, Jonathan, Winesap, Ben Davis, Anisim, Oldenburg and Wealthy taken from bearing trees. Frozen for 30 minutes. Temperature -15° to -40° F. One twig of Oldenburg and one of Wealthy were not injured. All others were killed back from one to three inches, the hardier varieties showing the less amount of injury. In this set the twigs had been allowed to become slightly dried out before freezing and it is significant that in all the tests made this was the only one in which any of the twigs appeared to be entirely uninjured. This indicates very strongly that the amount of water contained at the time of freezing is a controlling factor. All of the results show that the injury incurred is inversely proportional to the hardiness of the variety, but even the varieties which can withstand from 25 to 40 degrees F. below zero under natural conditions cannot withstand a sudden drop in temperature to even -10° F.

In conclusion it may be said that no single test was found which might be considered sufficient to distinguish in all cases between the hardy and tender varieties, but the various tests taken collectively are worthy of attention.

THE RELATION OF CLIMATE TO VARIETIES OF APPLES.

By R. M. WINSLOW, *Department of Agriculture, Victoria, B. C.*

The commercial apple industry of British Columbia is almost entirely a development of the last fifteen years. The census of 1910 showed only 8,000 acres of fruit in the Province, which increased by 1913 to 38,196 acres, an increase of 477 per cent.

Not only the commercial industry but the fruit-growing sections themselves are of comparatively recent growth. Orchards planted previous to 1910 were almost solely for home use; they were limited in number and usually were lacking in the standard commercial varieties of today. Our apple industry is being built up by incoming settlers principally from Eastern Canada and Great Britain, in a new country where there is little experience or experiment to gather from.

Under the circumstances, it was inevitable that a wide range of varieties should be planted. Preference was generally given to varieties successful or popular in the state of Washington, with some reference to marked preferences and a very considerable bias towards varieties familiar to the settler in his previous experience.

The Department of Agriculture had been especially active in promoting the fruit industry and upon it was thrown the considerable responsibility of giving technical information on varieties suitable for planting.

Much of the planting had been done when I came to the Province as Provincial Horticulturist in the Spring of 1909, but there was still a very large demand for information and this demand, more especially now with respect to top-working and replanting, still continues. In the absence of reliable local information, it was necessary to secure the most reliable information from other districts of similar character. We were fortunate in having weather records covering considerable periods for typical points in many of our new districts, and with these as a basis, were able to compare our climatic conditions with other already successful fruit sections.

The scientific study of the climatic requirements of even the most generally grown crops is not yet on such a basis as to make possible accurate statements of crop requirements as to temperatures.

I quote from Raphael Zon, Chief of Forest Investigations, in the "Monthly Weather Review" for April, 1914:

"With our present knowledge of the requirements of the various species, varieties, and biological races of plants for heat and moisture, we can only aim to compare the climate of a given locality with the climate of other localities in which the same plants are growing thriftily. For this reason what we need at present are not meteorological data of absolute accuracy, but rather data that will permit of an accurate comparison between the climatic features that are essential to plant life in different localities. The combination of purely meteorological and biological viewpoints in classifying and computing meteorological observations for purposes of botany seem to me absolutely essential. With our present meteorological observations secured at the weather stations, but with a different method of grouping them, it is possible to secure results which would be of value to students of plant life."

It is well known to horticulturists that varieties of fruits have distinct climatic preferences, some of them much more rigid than others. For the purposes of making more definite recommendations as to varieties we made a careful survey of all the recognized

commercial varieties of apples and reduced these to about 40 which were well suited to our market conditions and worthy of investigation from the standpoint of climate.

To put the main features of the growing seasons of different sections on a readily comparable basis we used a system proposed by the United States Biological Survey some years ago to determine the length of the growing season, the total heat units received during that season, and the average temperature of the six hottest weeks.

Length of the Growing Season. In a rough way this is usually gauged from the length of season between killing frosts. Investigation has shown, however, that for most plants of temperate regions, the period during which the mean temperature is over 43° F. is the growing season. From the mean monthly temperatures available as a result of many years work of weather recorders, it is easy to find the exact day on which the mean temperature, in its annual rise, passes the 43° F. point and, similarly, the corresponding day in the Autumn when the mean temperature passes below 43° F. The number of days between gives the length of the growing season in days, and in the agricultural parts of British Columbia it is usually between 175 and 140 days.

Number of Heat Units. The intensity of the growing season, as well as its length, is also of great importance. The sum total of heat during the season is expressed in heat units, and a heat unit is taken to be 1° F. for one day, for each day of the growing season. The heat units for each month are determined by multiplying the number of days in the month by the mean monthly temperature. If the month of July at Vancouver were to average 64° F., then the total heat units would be 64×31 , or 1984 heat units for the month. The other months are worked out in the same way, and also the part months at the beginning and end of the growing season. The total heat units vary widely in British Columbia agricultural districts, but are usually between 9,000 and 13,000 at various recorded points.

The Hottest Six Weeks. Also important is the average temperature at the height of the growing season. It is found that the summer heat is the principal factor in limiting the distribution of plants and animals southwards. The temperature of the hottest six weeks is also a good guide as to the ripening of vegetables and fruits. Districts which have the hottest six weeks temperature of 62° F. find great difficulty in growing even the earliest varieties of sweet corn and tomatoes, while those districts with a temperature of 66° F. for a similar period, grow these same crops in large commercial areas.

The temperature of the six hottest weeks has been found, by investigation, to be a very good guide to the intensity of summer heat. The given formula for determining it is simple; multiply the monthly mean temperature of the hottest month by 3, add the temperature of the next hottest month and divide the total by 4.

Example: If August monthly mean temperature is 68° and July 66° :

$$(68 \times 3) + 66$$

Then: $\frac{\quad}{4} = 67.5^{\circ}$ temperature of the six hottest weeks.

The determination of the length of the growing season, the total heat units, and the hottest six weeks, when once studied, are the greatest assistance, not only in determining the respective varieties of fruits, vegetables and fodder crops and grains likely to succeed, but incidentally, in conjunction with the monthly precipitation records, in relation to human life and preferences. The annual march of temperatures is shown in the table on pages 141 and 142.

ANNUAL MARCH OF TEMPERATURES.

Station	Length of Record	Mar.	April	May	June	July	Aug.	Sept.	Oct.	Nov.	Total	Growing Season	Heat units growing season	Temp., six weeks Hottest
Chilliwack.....	'01-'07: '11-'12: 9 yrs.	42.8	49.3	55.6	59.7	64.3	62.5	56.7	50.5	41.3	49.2	Mar. 17-Nov. 9. 237	13213	63.8
Vancouver.....	'01-'03: '06-'12: 10 yrs.	41.7	46.3	53.6	58.2	62.9	61.5	55.7	49.9	42.6	48.6	Mar. 26-Nov. 12. 232	12667	62.5
Victoria.....	'01-'12: 12 yrs.	43.6	48.1	53.5	57.5	61.1	60.1	56.3	50.9	45.5	49.8	Mar. 8-Dec. 4. 271	14409	60.8
Kamloops.....	'01-'12: 12 yrs.	38.6	49.3	58.4	64.3	70.0	67.4	57.8	47.8	37.2	47.3	Mar. 28-Oct. 28. 214	12683	69.3
Kelowna.....	'01-'12: 12 yrs.	36.5	46.5	55.7	61.0	66.7	64.1	55.0	45.7	36.4	45.5	Apr. 1-Oct. 23. 201	11507	66.0
Penticton.....	'08-'12: 5 yrs.	36.9	47.4	55.1	61.8	66.1	63.3	56.6	46.9	38.7	46.4	Apr. 3-Oct. 29. 209	11914	65.4
Vernon.....	'02-'12: 11 yrs.	35.5	46.4	54.5	61.1	67.2	64.5	55.6	45.7	34.8	44.8	Apr. 6-Oct. 22. 199	11423	66.5
Cranbrook.....	'01-'02: '04: '10: '11-'12: 6 yrs.	33.5	42.9	51.6	57.2	61.9	62.3	50.6	43.3	31.8	41.4	Apr. 16-Oct. 15. 182	9988	62.2
Golden.....	'02-'12: 11 yrs.	30.0	41.9	50.7	56.3	60.8	57.9	49.8	40.7	28.2	42.0	Apr. 19-Oct. 7. 171	9242	60.1
Elko.....	'10-'12: 3 yrs.	34.8	45.6	53.3	62.8	64.3	62.8	52.6	43.4	31.7	43.8	Apr. 8-Oct. 16. 191	10765	63.9
Nelson.....	'04-'12: 9 yrs.	37.4	46.8	53.7	60.1	65.7	63.0	56.0	45.6	37.0	45.8	Apr. 3-Oct. 22. 202	11427	65.0
Salmon Arm.....	'07-'12: 6 yrs.	36.2	46.1	56.2	62.2	66.5	62.8	55.6	45.7	36.0	44.8	Apr. 6-Oct. 23. 200	11488	65.5

ANNUAL MARCH OF TEMPERATURE.—(Continued.)

Station	Length of Record	Mar.	April	May	June	July	Aug.	Sept.	Oct.	Nov.	Total	Growing Season	Heat units growing season	Temp. six weeks hottest
Moxee (Yakima)	22 yrs.	42.5	50.4	58.1	64.7	71.2	69.4	60.0	49.9	39.3	19.9	Mar 18-Nov 3 230	13672	70.7
Spokane (Wash.)	33 yrs	39.7	48.2	56.1	62.2	68.9	68.0	58.4	48.2	37.8	48.0	Mar. 28-Oct 30. 216	12620	68.6
Boise (Idaho)		42.4	50.3	58.4	66.3	74.1	72.3	61.8	51.4	40.8	51.2	Mar 18-Nov. 8. 234	14185	73.6
Lewiston (Idaho)		45.2	52.8	59.5	66.5	74.5	73.0	63.3	52.9	42.8	53.1	Mar. 7-Nov 13. 251	15329	74.1
Hood River (Ore.)	30 yrs.	42.8	49.7	56.0	60.4	67.8	66.6	59.6	51.6	42.2	50.1	Mar 17-Nov. 12. 240	13756	67.5
Medford (Ore.)	3 yrs.	47.3	49.8	56.7	63.9	71.2	69.3	61.6	51.9	13.6	52.7	Feb 18-Nov. 14 273	15700	70.7
Hamilton (Mont.)	14 yrs.	37.5	47.0	53.1	59.8	66.1	64.9	56.5	46.6	34.4	45.7	Apr 3-Oct. 24 204	11587	65.8
Wolfville (N. S.)	9 yrs.	29.0	40.9	50.9	58.4	65.9	64.1	57.3	47.6	37.3	43.4	Apr 22-Oct. 28. 189	10769	65.4
Montreal (Que.)	50 yrs.	24.6	41.3	52.9	63.9	69.1	66.1	58.5	46.0	35.3	41.8	Apr. 20-Oct. 23 186	11052	68.2
Owen Sound (Ont.)	31 yrs.	27.0	41.0	52.0	61.0	66.0	65.0	60.0	48.0	35.0	43.3	Apr 21-Oct. 26. 188	10966	69.8
Hamilton (Ont.)	36 yrs.	24.0	43.1	55.3	62.2	72.0	63.2	61.7	50.0	42.0	45.4	Apr. 15-Nov 10. 209	12309	69.8
Bloomfield (Ont.)	07-12: 6 yrs.	31.2	48.1	52.9	63.1	68.8	66.4	60.3	47.9	36.2	44.1	Apr 6-Oct 27. 204	11963	68.2

The first three stations are typical coast sections of British Columbia. The second group of four stations is typical of the main dry belt area of British Columbia. The three points in the third group are typical of the second or high altitude dry belt. The two stations in the fourth group represent our humid interior sections. The seven stations in the fifth group are typical points in the seven main fruit sections of Oregon, Washington, Idaho and Montana. The five stations in the last group are typical points in apple sections of Eastern Canada.

Investigations of the behaviour of varieties in districts of similar climate as to temperatures showed very distinctly that other factors must be considered, and on making a study of precipitation records for such districts, it became obvious that the question of arid or humid areas and the variations between them are of very considerable importance. Accordingly, a statement of the monthly and total precipitation for the same stations and for the same periods of record is given on pages 144 and 145.

PRECIPITATION.

Station	Length of Record	Jan.	Feb.	Mar.	April	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Total Yearly Average
Chilliwack.....	'01-'07: '11-'12 9 yrs.	8.09	5.91	3.31	3.31	3.50	2.99	1.58	2.18	5.15	5.29	10.65	5.80	58.56
Vancouver..	'01-'03 '06-'12 10 yrs.	8.77	6.24	4.04	3.07	3.52	2.49	1.32	1.57	4.11	5.47	11.90	7.63	60.13
Victoria.....	'01-'12: 12 yrs.	3.87	2.85	2.00	1.08	1.21	0.70	0.36	0.70	1.79	2.26	5.93	4.33	26.88
Kamloops.....	'01-'12: 12 yrs.	0.92	0.74	0.21	0.40	.074	1.08	1.17	1.09	1.04	0.45	0.87	0.82	9.53
Kelowna.....	'03-'12: 10 yrs.	1.26	0.94	0.75	0.46	0.96	1.49	1.19	0.85	1.16	0.90	1.37	1.21	12.44
Penticton.....	'08-'12: 5 yrs.	0.84	1.27	0.37	0.42	1.30	1.18	1.02	1.35	1.11	0.72	0.85	0.76	11.19
Vernon.....	'03-'12: 10 yrs.	1.17	1.16	1.04	0.58	1.20	1.81	1.43	1.27	1.41	0.96	1.47	1.13	14.63
Cranbrook.....	'01-'02, '04, '10, '11, '12, 6 yrs.	1.89	1.23	1.26	1.18	1.59	1.62	1.21	0.87	1.18	0.83	1.37	1.63	15.86
Golden.....	'02-'03: '08-'12 7 yrs.	2.03	1.18	1.05	0.70	0.93	1.51	1.24	1.60	1.42	1.30	2.75	1.43	17.14
Elko.....	'10-'12: 3 yrs	1.78	1.26	1.22	0.89	2.38	2.72	2.15	1.86	1.71	1.31	2.71	1.34	21.33
Nelson.....	'04-'12: 9 yrs.	3.34	2.60	1.81	1.21	2.05	2.56	1.97	1.65	1.65	2.10	3.51	2.45	26.90

PRECIPITATION -- (Continued)

Station	Length of Record	Jan	Feb	Mar	April	May	June	July	Aug	Sept	Oct.	Nov.	Dec.	Total Yearly Average
Salmon Arm	07-12 6 yrs.	2.57	1.76	0.83	0.71	1.12	1.63	1.76	1.46	1.67	1.25	2.52	2.38	19.64
Moxee (Yakima)	22 yrs.	1.49	0.89	0.49	0.42	0.77	0.65	0.25	0.18	0.46	0.50	1.21	1.02	8.32
Spokane (Wash.)	33 yrs.	2.31	1.83	1.28	1.12	1.50	1.45	0.71	0.57	0.93	1.33	2.26	2.26	17.58
Boise (Idaho)		2.08	1.12	1.09	1.24	1.51	0.89	0.25	0.18	0.41	1.08	1.37	1.79	13.91
Lewiston (Idaho)		1.17	1.26	1.40	0.89	1.63	1.28	0.62	0.71	1.10	1.02	1.61	1.17	13.86
Hood River (Ore.)	50 yrs.	5.92	4.47	3.36	1.85	1.25	0.91	0.17	0.27	1.44	2.42	5.79	6.80	34.65
Medford (Ore.)	3 yrs.	3.56	1.36	1.01	2.71	1.89	2.00	1.06	0.05	0.90	0.72	2.62	1.95	19.86
Hamilton (Mont.)	14 yrs.	0.89	0.65	0.62	0.90	1.62	1.86	0.91	0.81	1.20	0.88	0.86	0.55	11.75
Wolfville (N. S.)		3.92	3.46	3.82	3.27	2.62	2.49	2.71	3.33	3.27	3.34	3.80	4.02	40.03
Montreal (Que.)		3.99	3.33	3.40	2.22	3.02	3.21	3.95	3.35	3.46	3.27	3.43	3.69	40.32
Bloomfield (Ont.)	08-11: 4 yrs.	1.60	2.99	1.33	2.58	2.63	1.77	2.37	2.44	1.65	2.39	2.32	2.31	26.43

If properly grown the Yellow Newtown is a desirable apple for export and for some home markets, and was popular with intending planters. It is notably limited in its successful ranges, our records show that the Hood River and Rogue River (Medford) sections of Oregon, where it does so well, have a long growing season, from 240 to 270 days, with from 13,750 to 15,700 total heat units, and a temperature during the six hottest weeks of 67.5° to 70.7°F. All of the few good Yellow Newtown sections are also humid areas, with irrigation, if at all, only supplementary.

As grown in sections of shorter season, the tree itself is vigorous and healthy, but fails to bear so heavily. The fruit also fails to mature properly. It has since proved only a medium bearer in our sections having only 11,400 to 12,700 heat units and a 200-day growing season, and in most years the fruit decays physiologically in April, May or June before developing the characteristic quality of the best sections.

It is interesting to note that in dry belt areas having the required heat and length of season, the Yellow Newtown, probably because of the intense insolation of the summer season, becomes an early winter apple.

A similar survey of the Esopus, also a notably sectional variety, showed that it requires somewhat similar climatic conditions, save that it is more adaptable to irrigated sections of similar temperatures. In Spokane, with 216 growing days, 12,620 heat units, and a six hottest weeks temperature of 68.6°F., the trees are not so productive, the fruit not so large or well colored nor of such desirable quality as that grown in more favorable sections. These considerations, added to the susceptibility to blight and to winter injury, decided us to strongly condemn it for general planting even in our most favored sections, and later experience has amply confirmed our opinion.

The Winesap is a great market favorite in Western Canada, is very generally grown in Washington, and is a long-keeping red dessert apple such as we much desire to secure. It is at its best, in size, color, and productiveness, however, in only a few sections, as the Piedmont of Virginia, and in the Wenatchee and Yakima Valleys of Washington. These are all possessed of long growing seasons, that in the Yakima Valley being from 230 to 240 days, with 13,700 heat units, and with average temperatures in the six hottest weeks of 70.7°F. Wenatchee has slightly higher records in all respects, which are not presented because the new station on the orchard level at that place is only two years old. The western humid sections, even those such as Hood River and Rogue River having as long or longer seasons and more heat units, fail in size and color, while in the Spokane and other irrigated areas of lower temperatures and shorter seasons the tree lacks vigor and productiveness, and the fruit lacks size and color. Even the most favorable recorded points in British Columbia, such as Penticton, are obviously lacking. The Kamloops section is more nearly suitable, having an average of 214 growing days, 12,683 heat units, and a six hottest weeks tempera-

ture of 69.3°F. The Similkameen Valley, of which unfortunately there are no temperature records, but which is believed from observation of its climate and flora to have the longest and hottest growing season in the Province, comes nearest to the requirements. We have accordingly advised strongly against planting Winesap except in these most favored sections where it has been largely planted, and in my opinion, will do pretty well for commercial purposes.

Jonathan is our most largely planted variety, and one we have studied with both hope and fear. It is doing very well in Washington areas such as Yakima and Wenatchee with a 230 to 240-day growing season, 13,700 heat units, and 70.7°F. average during the hottest period. It has a much wider range, however, than the Yellow Newtown, Esopus and Winesap, though on the Pacific Coast it is not succeeding commercially in the humid sections and we are finding the same true in British Columbia. In our Okanagan Valley where such points as Kelowna have a growing season of 201 days, 11,500 heat units and six weeks hot period of 66°F., it is bearing heavy crops of well colored, good quality fruit. The shorter, cooler season seems to tend to longer keeping, its season in the Okanagan being up to January in ordinary storage, as against December in Yakima. There is always a struggle for sufficient size, however, even in our best irrigated sections, and in seasons below average as to length or warmth, size and color are seriously short. In our interior humid sections as Salmon Arm and Nelson it is hardly in the commercial class. It seems to be on its northern limit of cultivation in our lower irrigated valleys.

The Wagener because of its early bearing has been much favored and it would seem to require very much the conditions found largely in our interior sections. It requires about the season of Spokane or Kelowna, with mild winters. While it does fairly well over a wide range of soil and location, I should not agree with some authorities in classing it as a distinctively cosmopolitan apple. The Spokane Valley is perhaps the only section on the continent where it is considered a first-class commercial apple. It has been widely planted in British Columbia interior valleys, but in those of even slightly cooler and shorter seasons than Kelowna, it lacks size and color. In such sections as Kelowna, it will probably justify commercial planting.

After investigation of the possibilities of many standard kinds, it became plainly apparent that suitable varieties would be those adapted to shorter and cooler seasons for which we turned to Canadian commercial lists.

The MacIntosh, of Canadian origin, has been succeeding commercially in such widely separated areas as Maine and the Bitter Root Valley of Montana. In growing season, Montreal and Ottawa, its home territory, are much like our interior sections, though with rather shorter seasons by about 10 days, and slightly higher temperature in the hottest period. The Bitter Root Valley (Hamilton, Montana, in the table) has conditions very similar to our lower dry belt (second group in the table). This variety appeared so

promising for both humid and arid sections that we have recommended it strongly. Its susceptibility to scab in humid sections was made known to growers and the amount of control necessary in different sections predicted. The plantings made six to nine years ago have already confirmed our recommendations and the variety shows every prospect of becoming our most important apple.

The Delicious which is so successful in Wenatchee, Yakima, and some other sections, is yet too little tried generally to yield much information by this method. In our warmest dry belt sections it is already doing well though it is not quite so productive as desired. It would seem to require a rather longer and warmer season. It is good in size, color, and quality, and is especially a fine late-keeper.

The great unsolved problem of British Columbia apple culture is to find a long-keeping, red, dessert apple, with a hardy, vigorous and productive tree. The same problem faces all the apple sections of Canada and sections of similar season in the United States. In the search for such a variety we have examined the requirements of practically all the commercial varieties grown on the continent and are even now testing a number of varieties from other countries. In this question the comparison of climatic requirements has at least enabled us to eliminate from general planting many varieties not worthy of extended experimental planting.

This paper is not intended to cover more than a hurried resume of the method we have used and its general results. It will, however, prove suggestive, and it is hoped, useful also, to other horticulturists in the comparative study of districts for all kinds of long season fruits.

PRESIDENT CORBETT: We have completed a long, interesting, and profitable program. It is a very remarkable circumstance, it seems to me, that a list of thirty-three papers should be offered and that twenty-five speakers should be present to read them. This is a remarkable achievement for any society. It clearly demonstrates the interest of the men in horticulture in their chosen profession and insures a long life for the Society. I hope that all future meetings may be dominated by the same spirit of helpfulness and co-operation which has pervaded this one and that they may be as successful as this one has been. The meeting stands adjourned.



W. L. HOWARD

PROCEEDINGS

...OF THE...

Society for *Horticultural Science*

1915.

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CALIFORNIA FIELD MEETING,
BERKELEY, CALIFORNIA,
AUGUST 31, 1915.

AND
TWELFTH ANNUAL MEETING
COLUMBUS, OHIO,
DECEMBER 28 and 29, 1915.

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 GUNSON, T. Agricultural College, East Lansing, Mich.

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 HENRICKSEN, A. P. University Farm School, Davis, Calif.
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 HERRICK, R. S. Iowa State College, Ames, Iowa.
 HIGGINS, J. E. Experiment Station, Honolulu, Hawaii.
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 HOLMES, F. S. Experiment Station, College Park, Md.
 HOOD, G. W. University of Nebraska, Lincoln, Nebraska.
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 HUSMANN, F. L. Second and Seminary Streets, Napa, Calif.
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PROCEEDINGS OF THE SOCIETY FOR HORTICULTURAL SCIENCE.

1915

CALIFORNIA FIELD MEETING AT BERKELEY, CALIFORNIA.

TUESDAY, AUGUST 31, 9:30 A. M.

PRESIDENT HOWARD: The meeting will please come to order.

Speaking for the fruit growers of California, I welcome the members of the Society for Horticultural Science to our state. We trust that you will avail yourselves of every opportunity to become familiar with our great diversified fruit industries. We hope that you will not only see the orange groves of the South, which are in the path of the tourist and most easily seen, but that you will also visit the valleys and foothills in order that you may see our deciduous fruits at home. In addition to our fruit-growing interests, we hope that many of you will find it possible to examine some of our leading vegetable-growing regions.

The local members of our Society, as well as the fruit growers and boards of trades of all parts of the state, stand ready to assist visitors in every way possible in order that they may become fully acquainted with the horticultural industries and resources of the state, if you will only let your wants be known.

We will now proceed with the program. I will ask Vice-President Coit to take the chair.

PRESIDENT'S ADDRESS; SOME OBSERVATIONS ON THE FRUIT-GROWING INDUSTRY OF CALIFORNIA.

BY W. L. HOWARD, *University Farm School, Davis, Calif.*

The history of fruit growing in California in a way is as full of romance as the history of mining. Fruit growing had its beginning in the state more than 150 years before gold was discovered. Wherever the Spanish Jesuits and Franciscans from Mexico established missions, they also established fruit growing. These old Spanish missions were scattered from San Diego in the South to the north end of San Francisco Bay in the North. When the Russians occupied a part of the region near the coast in the northern part of the state, they left their imprint upon the fruit growing of that region. This was about 1812. As other settlements were made in the state during the 30's and 40's fruit growing was extensively practiced. When the church lost its power in the state in 1834, the missions fell into decay and the splendid orchards that had been so well cultivated and cared for rapidly declined. With the rush of

miners and settlers into the state in the early 50's the incentive to grow fruit became very great as the market for fruits of all kinds was then practically unlimited. Naturally the fruit growing business has undergone many changes to keep pace with the development of the state.

The present, it seems to me, is a transition period in California horticulture, but Professor Wickson tells me that there have been several transition periods. I need not enumerate or give statistics on the size of the industry at the present, or the relative importance of the different fruits, for all of you know about these things, at least in a general way. It seems to me that the present is a period of change because many of the orchards are now growing old and new methods of maintaining their vitality and fruitfulness must be devised. Systems of packing and marketing that were once adequate must now be revised to meet the ever-changing requirements of the times. Tillage problems that so long gave the growers of California no concern because it seemed that their soils would never fail, are now requiring more and more attention. The help problem in the past has largely been solved by leasing the fruit lands in small tracts to persons who under other circumstances would have been the hired hands. The struggle for markets which began with the production of the first crops which were larger than the state itself could consume, is still on and growers appear to be perfectly able to meet changing conditions and from time to time re-adjust their business so that they have always been able to sell all that they have produced.

One thing the Californian in no line of business has had to combat, is tradition. The fruit grower, particularly, has never been tied to any practice simply because it happened to be one that had been followed by someone else in the vicinity. Those of you who have lived in old settled regions know the difficulties of getting a farmer to change his practices. The California fruit grower does not look upon any old practice with reverence, and is quite ready and willing to change if he can be shown a better way of doing things. To my mind this is the secret of the rapid development of many regions in the state. If a line of fruit growing practiced in a certain valley or district proves to be unprofitable, the grower does not throw good money after bad by trying year after year to save something out of the wreck, but he immediately uproots the trees and plants something else, or, if they are capable of top-working he grafts them to something that is profitable. In other words fruit growing is a main line rather than a side line throughout most of the state. This accounts for the fact that there are no neglected orchards. If a man neglects an orchard in this state by failing to cultivate, or irrigate, or prune, it will either decline and die or become so unprofitable that he gets rid of it in short order.

It has been said that the farmers of the country as a class are the hardest of all people to organize. This has been cited as a reason why fruit growers' associations of the East and Middle United States have been so hard to start and hold together after they are

started. I may say that the California fruit grower fundamentally is not unlike his brothers in other states; however, his distance from markets and his helplessness as an individual have driven him to combine with his neighbors. If he could make half a living as many fruit growers do in other states without organizing, many would undoubtedly be content to do this. This is especially true of the newer residents of the state. However, there is a trait of character peculiar to many of the native born growers that is peculiarly Californian. This is that he is not satisfied with small profits. The early history of the state, particularly after the great rush of the early 50's began, favored large profits in many undertakings. People took to growing fruit in the early mining days because the business paid better than mining. When the first California fruits began to be shipped to the eastern states, the results in a way were like the early gold discovery. Since those days many of the growers have not been content with anything but big profits. With no crop failures like eastern growers have to contend with, it has always been possible, if a certain variety of fruit lost its popularity, to graft the trees over to some other variety more in demand. At the present time when other regions have encroached upon California fruit industries, new adjustments must be made in order to meet the changing conditions. However, there are certain fruits peculiar to the state that thrive so well and which can be grown here to a better advantage than elsewhere, that they will very likely always be grown in California on a large scale. I have reference particularly to the citrus fruits, the European grapes, certain of the nuts, apricots, almonds, certain varieties of pears, peaches, plums and especially prunes. From a luxury the California fruit grower has caused certain fruits to become necessary articles of food. This is particularly true of the prune, and certain of the evaporated fruits such as the pear, apple, peach and apricot. California canned fruit is a staple wherever groceries are sold.

While the California fruit grower has many problems to solve—far more than he had in the past—he is versatile; is not hampered or handicapped by tradition; is in the business on a large scale as a rule and, therefore, has capital to develop his business; and in every way is able to meet changing conditions; and it is certain that he is in the business to stay and that he cannot fail to make a success of it in every sense of the word.

VARIATION IN MINIMUM TEMPERATURES DUE TO THE TOPOGRAPHY OF A MOUNTAIN VALLEY IN ITS RELATION TO FRUIT GROWING.

BY L. D. BATCHELOR, *Citrus Experiment Station, Riverside, Calif.*

(The investigations discussed in this address will be published as bulletin No. 141 of the Utah Experiment Station with which Dr. Batchelor was connected when the investigations were made.)

THE AVOCADO INDUSTRY IN CALIFORNIA.

By I. J. CONDIT, *University of California, Berkeley, California.*

The avocado industry in California is in its infancy; properly speaking it can hardly be said to have reached sufficient importance to be classed as an industry. Enthusiasts lead us to believe that the future avocado acreage in this state will be greater than that of citrus fruits, reminding us that the fruit has real food value, not being (to use their own words) a mere confection such as the orange and lemon. Whatever the future importance of the industry may be, the fact *now* is that the propagation of trees and the production of fruit from these trees is absorbing the attention of an increasingly large number of persons. The rather sudden interest in avocado planting can be accounted for by the abundant fruiting of many large seedling trees in Southern California and by the high prices received for the fruit in the local markets. Many orchards ranging in size from a fraction of an acre to five, ten and even twenty acres, have been planted, and much larger plantings are contemplated. The present acreage is probably considerably less than two hundred. There is little doubt that this will be doubled or even tripled in another year if a sufficient supply of trees is available.

The importance of putting this infant industry on a firm foundation was realized recently by many interested parties and a conference was held in Los Angeles May 14, 1915, with the result that there was effected an organization known as "The Ahuacate Association of California," with sixty charter members. The objects of the association are as follows: The prevention of errors which are bound to occur in any new industry; the dissemination of cultural and other information; and the education of the public concerning the uses and the food value of the fruit. After considerable discussion by several growers present at the meeting, it was decided to use the word "ahuacate" rather than "avocado" for the fruit and for the name of the organization. Dr. Franceschi of Santa Barbara has long advocated the adoption of the name "ahuacate" in place of "avocado," which, as he says, has no meaning and no historical sense. On account of the fact that such a comparatively small number of people are familiar with the fruit handled by commission men under the name "alligator pear," it was the opinion of the association that the correct name "ahuacate," which has been the name of the fruit since the time of Cortez' invasion of Mexico, could be brought into common use as easily as the less correct one, "avocado." The word avocado "is the past participle of the Spanish verb 'avocar' meaning, 'to call up by a superior from an inferior', generally used in times past by a superior judge taking a case out of an inferior judge's court without the necessity of an appeal. The practice is obsolete now and the word has fallen into disuse. The Century dictionary also gives it as a corruption of the Spanish word 'abogado' meaning advocate".*

▲▲ As early as 1696 Hans Sloane† wrote of the “avocado or alligator pear-tree” and listed several other names appearing in literature at that time. De Candolle in 1882 referred to the fruit as avocado or alligator pear, stating that the name avocado is a corruption of the Mexican *ahuaca*, or *aguacate*. In 1902 the Florida State Horticultural Society expressed itself in favor of the name avocado, while in 1901 and 1903 the American Pomological Society listed the names in the following order, *aguacate*, avocado, alligator pear. In its list of fruits recommended for planting in the United States published in 1909 the latter society used the name avocado with no mention of other names. Other references to literature in which English writers have used the word avocado may be noted as follows:

John Lindley—Transactions of the Hort. Society of London, 1824.

Chas. Knight—A Description and History of Vegetable Substances Used in the Arts, 1829.

John Lindley—Botanical Register, No. 1258, 1829.

W. J. Hooker—Botanical Magazine, Plate 4580, May 1, 1851.

Sir Robert H. Schomburgh—Journal of the Hort. Society of London, 1847.

E. J. Hooper—Pacific Rural Press, Nov. 18, 1871.

Geo. Nicholson, in the Dictionary of Gardening, 1887, uses Alligator or Avocado Pear.

L. H. Bailey, in the Encyclopedia of American Horticulture, Edition of 1901, uses Alligator Pear, Avocado Pear, Aguacate, Midshipman's Butter. In the Edition of 1914 he uses Avocado.

Since the use of the name avocado has thus been officially sanctioned by the societies mentioned as well as the United States Department of Agriculture, and its occurrence in English literature has been so frequent during the past century or more, it would seem that the attempt to introduce another name at this time would not only be ineffective but would result in even greater confusion than at present so far as the general public is concerned. It is interesting to note that one prominent member of the Ahuacate Association expects to ship his fruit under the label Alligator Pear, with Ahuacate in parenthesis; another will label his fruit Alligator Pear with Avocado in parenthesis.

The avocado was first planted in California at Santa Barbara in 1870. Probably the oldest fruiting tree in the state is the Miller at Hollywood, first planted in 1886, but transplanted to its present location several years later. The largest tree in California is the Chappelow near Monrovia; it is over forty feet high and the branches spread over sixty-five feet. The girth of the trunk three feet from the ground is seventy-one inches. Other large seedling trees which have produced abundantly are to be found in and around Los Angeles, Orange, Whittier, and Pasadena. Seedling

* Letter from E. G. Hart.

† Catalogus Plantarum quae in Insula Jamaica, London, 1696, p. 185.

trees several years of age are to be found at Visalia, Los Gatos, San Luis Obispo and Napa, while near the Center Street entrance to the University campus at Berkeley, there is a tree at least twenty years old which is in a thriving condition, but which so far as known has never blossomed. The southern part of the state including San Diego, Los Angeles, Orange, Ventura and Santa Barbara Counties, has shown itself to be well adapted to the avocado tree and it is there that the largest plantings are being made. Trees are being planted out to a small extent in practically all the citrus belts of the state with the exception of Imperial Valley where the extreme heat has so far destroyed young plants in the open ground. Just what the geographical limits of successful avocado culture will be, no one can definitely state at present. It is generally believed, however, that some varieties of avocado can be grown profitably wherever the orange, lemon, and pomelo thrive.

What, then, are some of the factors which limit the healthy growth of the avocado tree in California? As already stated the extremely dry heat and sunshine of the valleys bordering the desert have so far proved fatal although it may be possible in the future to develop a type of tree whose foliage will successfully withstand such conditions. The amount of frost which an avocado tree will endure depends first upon the kind of tree, those bearing thin-skinned fruits ordinarily being hardier than those bearing the larger hard-shelled fruit; second, the condition of the tree, dormant trees being able to stand much more cold than trees in a growing state; third, the weather conditions following a freeze; and fourth, the duration and extent of the low temperature. Some avocado trees in California have not been seriously injured by temperatures as low as 10° F. although the fruit and blossoms were killed; other trees have been injured by 3° or 4° of frost, while the strictly tropical varieties will not withstand even cold, frostless nights, the leaves and tender branches turning brown and dying back under such conditions. Varieties which bloom late enough in the spring to escape heavy frosts should be preferred for commercial planting. The avocado fruit itself when fairly mature is not injured by low temperatures which seriously injure the leaves and branches. Immature fruits drop to the ground when the stems are frozen.

Another factor to be taken into consideration is the wind. There are comparatively few sections of California which are not subject at certain seasons of the year to rather violent winds. Scores of avocado trees are now planted out in situations where they would undoubtedly thrive were it not for the damage done by the wind to the broad leaves and brittle branches. The original trees of the Taft, Rhoad, Ganter, Challenge, and Royal varieties, have all been protected from wind by immense lath shelters in some cases thirty feet high, which also serve as supports to keep the branches from breaking down under the great weight of fruit. Young trees of most varieties require staking during the first two or three years in the orchard to keep them from growing crooked under the force of the wind.

So far as soil is concerned the avocado is no more particular than the citrus tree. There must be good drainage and considerable depth to the soil for the best development of the tree.

In California the avocado tree is propagated almost exclusively by budding. Cuttings may be and have been rooted to some extent, but this method is not used commercially. Nurserymen prefer the seeds of the thin-skinned Mexican type of avocado for the production of seedlings on account of their greater hardiness. Because of the scarcity of seed, however, many thousand trees have been budded on seedlings of the hard-shelled Guatemalan type of fruit. The seeds of this type, being larger, produce seedlings of budding size somewhat sooner than those of the thin-skinned Mexican type, but the former are tender and succumb much more readily to frost than seedlings of the latter. Whether there is any appreciable effect of the different stocks upon the hardiness of the resulting tree has not been demonstrated. The supply of seed of the thin-skinned Mexican type should be amply sufficient in a year or two since individual trees of this type growing in California have been known to produce in one season 5000 fruits of the size of an egg. Avocado seeds are planted whenever obtainable either in pots, in seed beds, or in the open ground. The method of propagation used by most nurserymen is as follows: Plant the seed in pots or seed bed in December, January, or whenever obtainable, transplant to the open ground as soon as the seedlings are six to eight inches high, and bud whenever the bark is slipping. If budding is performed in October or November, the buds remain dormant until early spring. The nursery trees are transplanted, by balling, most successfully when about one year old, the month of March being largely preferred.

For some reason, not yet known, nurserymen have been unable to propagate by budding any large percentage of trees of at least three varieties, each of which, however, bears fruits of desirable size, shape, and quality. The original trees of two of these varieties, the Dickey and the Murrietta, are growing in Los Angeles and are healthy, vigorous, and productive. Buds placed in seedlings start to grow, but after a few weeks almost invariably cease their growth and either die, stock and all, or struggle along in a weak, sickly condition season after season. With some varieties the supply of good budwood is limited and the nursery prices for the trees of such varieties are relatively high, the Challenge being a good example of such a variety. One nurseryman budding into the same stock used for other varieties, and using the best Challenge buds he could find not only from the old tree but also from young trees, could get not over a 20 per cent stand. One reason why the variety known as the Harmon has been so largely planted is that good buds are plentiful, they unite readily to the stock, and grow rapidly into symmetrical orchard trees. The present price of seeds is about 4 or 5 cents each, of buds 2 to 10 cents each, and of budded field-grown trees \$2.00 to \$5.00, depending upon the variety.

The heavy production of many of the large seedling trees in

Southern California is remarkable. The account of the Ganter tree at Whittier, from which was sold in one year \$1500.00 worth of fruit and \$1700.00 worth of budwood, seems to be authentic. During the past season the Challenge tree at Hollywood produced 1540 fruits for which the owner received \$756.36. In this connection the record of the Chappelow tree at Monrovia is interesting; the tree was planted in 1893 and began bearing in 1898. Since 1902 it has produced as follows:

1902.....	310	fruits
1903.....	380	"
1904.....	605	"
1905.....	575	"
1906.....	235	"
1907.....	465	"
1908.....	1209	"
1909.....	260	"
1910.....	285	"
1911.....	1023	"
1912.....	350	"
1913.....	Year after freeze, about 20 fruits	
	July	34 fruits
	Aug.	113 "
1914.....	Sept.	1051 "
	Oct.	1602 "
	Nov.	457 "
	Dec.	36 "
Total		3293 "

The variation in production is probably due to the fact that the tree blossoms very early and the flowers are apt to be damaged by frost.

The range in the price of avocados during the past season has been from a few cents for the small black or green seedling fruits to 75 cents and one dollar for larger specimens such as the Taft and Lyon. The prospect of immediate gain from the sale of fruit at such prices was naturally a great temptation to some growers who therefore picked and marketed the fruit before it had properly matured on the tree. A grower can hardly be criticised, however, for so doing when buyers come to the tree with cash in hand and almost demand fruit for a special occasion. This naturally raises the question as to just what stage of maturity the avocado has the greatest food value as shown by the maximum oil content, a subject not studied here so far, but which we hope to investigate the coming season.

So far there have appeared no serious pests of the avocado in California although it is known that there are several insects and fungi which attack the tree and fruit elsewhere. Shipments of avocados into this state from Hawaii are prohibited on account of the danger of introducing the Mediterranean fruit fly in the fruit.

Shipments from Mexico are no longer made since the seeds of some Mexican varieties are infested with the avocado weevil, *Heilipus Lauri*. Occasional shipments of one to two hundred crates are being made into California from the Island of Tahiti where the fruit fly has not so far been found; the value of these shipments amounted in 1912 to \$2,004.00, in 1913 to \$2,519.00, and for the first ten months of 1914, to \$2,429.00. During the fall months avocados from Florida are more or less common in our California markets.

Minor insect attacks may be noted as follows: Mealybug, greedy and black scales in Ventura and southern coast counties; a species of *Crabro* which infests the twigs of young trees in Butte County, the omnivorous looper, *Sabulodes cabrata*, the larvae of which were commonly found on seedlings at Berkeley; the twig borer, *Polycaon confertus*, and a chafer, *Serica alternata*, both of which have done injury to nursery trees in Ventura County; and an unidentified miner, the galleries of which have been noticed on the tender branches of nursery trees in various parts of Southern California. A leaf trouble, probably similar to that occurring in other countries and due to a species of *Gloeosporium*, is very commonly found on young trees. It has been the experience of some growers that certain varieties seem to be more or less resistant to the attacks of this fungus, one variety, the Champion, grown at Orange, not being affected at all. The fruits of some varieties, notably the Ganter, Harmon, and Blake have a tendency to ripen and turn dark at the apex first if left on the tree too long. While this may be due to some fungous disease its exact nature is uncertain; the softening and darkening can be largely avoided by picking the fruit at the proper stage of maturity and allowing it to ripen off the tree.

Probably the most important and at the same time the most perplexing question confronting avocado planters today is that of varieties. At least twenty-five varieties of California origin have already been described and doubtless as many more are being propagated and heralded by enthusiastic owners or nurserymen. In addition, more than a score of varieties from other countries have been introduced and are being propagated by the thousand in some cases. The unbiased opinion of several persons who have travelled in Mexico and other countries and eaten avocados from native trees, is that the commercial varieties of the future have not yet appeared; others claim that some California varieties have no superior anywhere. California seedlings which have been fruiting for a number of years have a decided advantage, as it is already known how they will thrive under certain California conditions. The requirements of a good commercial variety of avocado may be stated as follows:

1. The bud of such a variety must be able to grow into a vigorous upright, orchard tree. Many seedlings which bear excellent fruit will probably have to be eliminated on account of their poor habit of growth when propagated. Allow me here to quote the experience of a prominent grower in Southern California as an example: "Four years ago I planted an orchard of a certain well-

known variety. The trees are now five years old from the bud. They are as large as full-grown orange trees and beautiful to look at. I expect a considerable crop this year. I planted at the same time on adjoining ground an orchard of another variety. I was sorry at the time that I did not have more of this last named kind and less of the others. The parent tree seemed strong and healthy, but the young budded trees, when placed in the orchard, made poor growth, suffered from cold and were in due time taken out and replaced with another kind. These, also a failure, were in turn removed and still another variety substituted. Now I am taking out this third lot and planting the variety growing in my five-year-old orchard. This time I am going to have trees, though they do not bear fruits weighing two pounds each."

Several large collections of trees representing all the principal varieties are now growing in various parts of the state and it will be very interesting to observe the habits of growth of these varieties under the different local conditions.

2. The tree of a good variety should be sufficiently hardy to withstand ordinary frosts. It seems reasonable to believe that the best varieties of avocados from the highlands of Mexico and Guatemala will thrive wherever lemons are successfully grown.

3. A good variety should be fairly precocious, prolific, and a regular bearer. Many of the California varieties are remarkably precocious; some are too much so. A budded tree which blossoms in the nursery row as does the Lyon almost as soon as the bud starts, cannot at the same time make the wood growth which is sufficient to support future profitable crops. On the other hand a variety which does not show any disposition to blossom in the four or five years after budding is rather disappointing to the grower who desires early returns from his tree, even though it may produce most excellent fruit in later years. A variety therefore which develops during the first two or three years into a vigorous symmetrical tree and then gradually comes into bearing is to be preferred.

The prolificness of some of our California seedlings has already been discussed. Viewing the subject from a commercial standpoint alone it would be more profitable to handle 300 fruits from a tree such as the Taft or Lyon at 50 cent each than 600 fruits of a variety such as the Harmon or Chappelow at 25 cents each. If the high production of such a variety as the Challenge can be maintained, it may be more profitable to the grower even though the quality of its fruit is somewhat inferior.

Avocado trees have not been growing for a sufficient length of time or in sufficient numbers in California to show to what extent regular crops can be produced. Barring unfavorable climatic conditions such as frosts or rain at blossoming time, a good variety should bear regularly if the grower keeps the tree in a healthy condition and does not allow it to overbear in any one season. In Mexico some trees are said to bear more than one crop in a year and this is true of at least two varieties in California. The Northrup bears a small spring crop and a large fall crop; the White at Santa

Barbara has shown a tendency to produce three and even four distinct sets of blossoms and fruit.

4. The tree of a good variety should blossom late enough for the flowers to escape occasional spring frosts. It has long been recognized in this state that trees bearing thin-skinned fruits blossom earlier than those bearing hard-shelled fruits. A study of the table of varieties shows the following dates of blossoming: Thin-skinned varieties, Chappelow, November to March; Topa Topa, January; White, February; Northrup, April; Harmon, April; Azusa, Carton, Ganter, and Hathaway, January; hard-shelled varieties, Wagner, February to March; Challenge, Walker and Royal, March and April; Solano, May and June; Taft, April and May; Dickinson, April and May. For the most part these dates seem to corroborate the fact mentioned above.

5. The fruit should be of good flavor and quality. The flavor and quality of any fruit are to a certain extent matters of the personal opinion of the consumer. Many of the thin-skinned Mexican avocados are of superior flavor. This is supposed to be due to the higher oil content as shown by analysis. The flavor of one large-fruited variety was long ago described as insipid and watery. Recently this variety was analyzed for the first time and found to average but 3.85 per cent of fat. The fiber so noticeable in the pulp of many imported avocados is only slightly noticeable in the California varieties.

6. The size and shape of the fruit should be uniform and not too large, approaching round, rather than "bottle necked" and averaging about one pound in weight. The Sharpless is the only California variety producing a large, hard-shelled fruit having a prominent neck. The Chappelow and Blake are examples of thin-skinned fruits which are prominently "bottle-necked." Theoretically an oval or round fruit will pack to better advantage than an elongated fruit; practically, however, the shape of the fruit will probably have little effect upon its marketing qualities if other qualities are good.

7. The fruit of a good variety should be well adapted to shipping. Very little is known about the shipping qualities of the California varieties. While those varieties having a thick, granular shell are undoubtedly less susceptible to bruises than are varieties having a thin skin, it is by no means certain that they will keep in better condition during shipment and while on the market if the latter are carefully handled. Even should it be found impracticable to ship thin-skinned fruits to Eastern markets and have them arrive in condition to sell in competition with hard-shelled fruits from Florida and the West Indies, such fruits will always be in demand in the local markets and for home use.

8. The seed should be small and tight in the cavity. Studies of a large number of varieties show that the size of seed in the round avocados is proportionately greater than in the pear-shaped fruits. For example the Challenge and Florida Trapp, typical round fruits, show 26 and 20 per cents, respectively, of seed to the whole

fruit. Some of the typical pear-shaped varieties show the following percentages of seed: Taft, 18; Miller, 16; Sharpless, 12; Solano, 9.9; Royal, 15.8; Lyon, 25; Blakeman, 14.

Various writers have emphasized the importance of having the seed of an avocado fill its cavity. Just how important this character is has not been determined by careful shipping experiments. In most of the hard-shelled fruits grown in California the seed is tight in the cavity; in a few of the thin-skinned varieties, namely the Ganter, Blake, Harmon, and Mattern a large percentage of the fruits has loose seeds which move about in the seed cavities. The majority of specimens of the Florida-grown Trapp and Cardinal which I have examined, has had loose seeds, but the flesh around the cavity did not show any appreciable darkening. A Florida shipper has communicated with me as follows regarding this point: "We do not favor the planting of any loose-seed varieties in a commercial way. Of course the seedlings are apt to be either loose or solid, but the budded varieties now in favor are all tight seeded. The Trapp is so far our best commercial variety and is almost always found to have a tight seed. When packed in excelsior and reasonably handled, the loose seed should not injure the fruit unless it is too ripe. However, it is an additional risk and considered a defect."

During the past year the California Experiment Station has made analyses of a large number of varieties of avocados, the results of which have been published in Bulletin 254, Part II, entitled, "The Composition and Food Value of the Avocado." Especial mention should be made of the following points brought out in this bulletin. The average percentage of dry matter for the avocado is 30.84. The nearest approach to this figure is found in the banana with about 25 per cent dry matter. Sugar and starch predominate in the banana as against fat in the avocado. So far as protein content of various fresh fruits is concerned, the avocado stands far in the lead, having a maximum percentage of 3.7, and a minimum of 1.3. The mineral matter in the avocado is much greater than that found in any fresh fruit although detailed analyses of the ash have not been completed. The average percentage of ash of 28 varieties is 1.26, only slightly below that in dates.

Since the chief value of the avocado as food is due to its high fat content, growers of any variety have been especially interested in learning the percentage of fat as shown by analyses of their fruit. The average fat content is shown to be 20.1 per cent of the edible portion while the maximum is 29.1 per cent. A table giving the percentages of fat or oil in the varieties of the avocado and olive respectively show that the avocado ranks higher in this respect than the average or commonly used olive. The latter fruit is not consumed fresh, except by the unsophisticated tourist, and should be classed as a processed rather than a fresh fruit.

Mention has already been made of the superior richness and quality of most of the thin-skinned Mexican avocados. The average fat content of thirteen such varieties recently analyzed was 22.16

per cent, while the average of fourteen hard-shell varieties was 14.13 per cent. It is a well-known fact that in Mexico, the natives and others who appreciate the difference, prefer the small thin-skinned "paltas", scorning the large "paguas" as inferior in quality and flavor. The commercial grower must therefore take into account both the eating qualities and the market qualities of a variety of avocado.

During the past few months many predictions have been made by various persons regarding the future of the avocado industry in California. Almost without exception these expressions are very encouraging to prospective planters and to those who are interested in the development of the industry. The most common question asked of avocado men today is, "Do you really think the avocado will become an important commercial fruit?" and they usually answer "I really think so". It is not only the nurseryman who has trees to sell who thus expresses himself, but conservative business men, experienced ranchers, and others who have been watching the fruit for many years both here and in other countries. It is of course conceded that there will be many failures, that scores of trees now planted will never come into bearing, and that some varieties which look promising at present will prove of little value in the light of future experience. I believe with others, however, that commercial avocado culture offers very bright prospects at present if the grower plants good healthy trees of the proper varieties in an approved locality and uses good business judgment as well as common sense in handling his orchard and marketing his fruit.

TUESDAY, AUGUST 31, 1:30 P. M.

THE SCIENCE OF ORCHARD HEATING.

BY CARL NICHOLS,

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In the short length to which I must confine my paper, it will be impossible to consider the subject of orchard heating in its entirety, but I shall endeavor to give a brief review of the history of the development of frost protection devices, and also to describe briefly those forms most approved at present.

The protection of trees and plants from frost injury dates back perhaps two thousand years. O'Gara states that the Romans practised heating and smudging as a protection against frost injury. Smudging with wet straw and half-rotten manure was recommended by Olivier de Serres, a French agriculturist, in the sixteenth century, and in the latter part of the eighteenth century smudging is said to have been compulsory in parts of Germany. Boussingault, the celebrated French chemist, states that the Indians of Peru have used smudges for centuries on the plains of Cusco in order to retard the loss of heat from the soil and plants. Some of the earlier work

in frost prevention was not so crude as one might suppose, for, during the eighties and early nineties, we find the French vine growers using heavy oils as a fuel, this oil being burned in flat earthenware dishes. Even systems of automatic lighting were devised which were operated by a mercuric column somewhat similar to our present automatic frost alarm thermometers.

At about the time that the French vine growers were carrying on their work in frost prevention, California and Florida orange growers began to experiment. The use of wet straw and composts had been common for several years, and in the early nineties when the oil industry of southern California was first coming into prominence, Charles Fronde introduced the first oil heater. This heater was later improved by J. P. Bolton, formerly United States Weather Observer at Fresno, California, and he developed the present Bolton or lardpail type. The severe frosts of December, 1895, in southern California brought about a greatly increased interest in frost prevention devices and at this time the Riverside Horticultural Club, composed of growers of citrus fruits, in co-operation with the United States Weather Bureau, made numerous tests of smudging devices, heaters and vaporizers. From the results of their experiments they concluded that the most efficient method of frost protection was to be obtained by burning coal in small wire baskets suspended a few feet above the ground. From that time until the present, coal heaters of various forms have been used in a considerable number of the citrus orchards in the south. But it was not long before oil heaters began to show their superiority and during the disastrous freezes of December, 1911, and January, 1913, numerous forms of oil heaters were widely used for frost protection in the citrus orchards.

The first and most important way by which the orchardist may avoid frost injury to his trees, is to choose a site for the orchard which is reasonably free from severe cold. As all methods of artificially preventing frost injury are expensive, those situations where artificial prevention is seldom, if ever necessary, should be given first preference for our tender fruits. In choosing such situations we should remember that freedom from frost depends more upon local topography than upon latitude. The bench lands and gently sloping sides of the hills surrounding the mountain and river valleys are usually the freest from frost, while the lowlands and bottoms of the narrow valleys are usually the coldest lands. The commonly accepted theory has been that this condition is caused by what is known as inversion of temperatures. Normally the temperature of the air decreases as we go upwards, but on still nights when danger from frost is greatest, the surface soil cools by radiation and the air in contact with it cools rapidly by conduction, this cold air at the same time becoming heavier. On a flat plain this cold heavy air will spread out over the surface and will grow gradually colder and colder. But on a hillside or on bench-lands this heavy air will flow quietly downward, collecting in the lowlands, while the warm lighter air floating on top, spreads out to the

hillsides and imparts to them some of its heat. Regions such as these, where frost seldom occurs, are often spoken of as thermal belts, verdant zones, or life zones. It should not be forgotten, however, that none of these belts are entirely frost free, for even they are subjected to severe freezes in occasional years (as in January, 1913,) when the cold north winds swept over the mountains and down the slopes on the other side carrying the whole mass of warmer air before them.

Once having made a proper choice of a location, the grower must then rely for further protection upon artificial methods and appliances. One of two results is sought in all methods of frost injury prevention, namely: (1) to hold the temperature of the air in contact with the tree or plant above the danger point, (2) to prevent rapid thawing of the plant tissues in case they are frozen. Attainment of the first result is more important than that of the second. In the accomplishment of these results the following methods have been employed: (1) conservation of the heat of earth and plants by lessening loss of heat through radiation; (2) raising the dewpoint by adding moisture to the air and thus making the latent heat of condensation sensible at temperatures above the danger point; (3) thoroughly mixing the lower air strata, thus preventing the formation of cold air layers next the surface of the earth; (4) screening plants and trees from the direct rays of the sun in the early morning; (5) adding heat directly to the air.

The first method—lessening loss of heat through radiation, and also the fourth method—prevention of rapid thawing, may be accomplished by covering plants or trees with various shelters such as lath or cloth screens, or it may be accomplished by filling the air above the plants or trees with a dense smoke or smudge, or with water vapor. The second method—raising the dewpoint, may be accomplished by filling the air with moisture through burning damp straw or manure, or by actually spraying water into the air from nozzles and sprinklers attached to pipe-lines. The third method—prevention of the formation of cold air strata through mixing, has been accomplished by the use of electric fans and blowers. The fifth method—the adding of heat directly to the air, has been accomplished by means of electric heaters suspended in the trees, by conducting steam or hot water through the orchard, and by burning various combustibles such as straw, trash, wood, coal and oil.

Although a few years ago the first three methods were considered to be the only practicable ones whereby frost injury might be prevented, these are almost entirely neglected now and the direct addition of heat to the air is considered to be the most efficient, practical and economical method for the protection of large areas of trees and plants from cold. As to the kinds of fuel used for this direct addition of heat, at first straw, trash and wood were much used and are used yet to some extent in the deciduous orchards of Oregon and Washington. But the great advantages of coal and oil as fuels soon became apparent and these two materials are now used exclusively in the citrus orchards of California. The methods

of heating by means of steam, hot water and electricity, have been tried out at various times, but have so far proven impracticable, the first two because of the great expense involved, and the second because sufficient electrical energy is not available in any one orchard district.

As between the two methods of heating by burning coal and by burning oil, the advantage seems to rest largely with oil heating. The coal heaters have some points in their favor in that they give off a goodly proportion of heat units and but little smoke and are cheap in cost, but the disadvantages are several, namely: (1) difficulty of filling and lighting the heaters, thus greatly increasing the cost of labor; (2) impossibility of regulating the heaters so as to obtain more or less heat according as the temperature of the air falls rapidly or slowly; (3) impossibility of extinguishing the heaters when once lighted, thus necessitating the burning of all the fuel in the heater after once lighted whether the air temperature warrants the same or not. Despite these difficulties, however, coal heaters are still used on one or two of the larger citrus ranches such as the Leffingwell Ranch near Whittier.

The almost universally accepted method at present then, of protecting trees and fruit from frost injury, is by the burning of crude oil or distillate in some form of sheet iron receptacle. Many forms of oil heaters have been tried out. The simplest form of all, the Bolton or lardpail type, is still used to some extent in California and is quite widely used in the deciduous orchards of Oregon where its use is recommended over other more elaborate forms by the Agricultural Experiment Station. The larger and more elaborate forms are, however, largely superseding the simpler types in the citrus orchards of California. The requirements of an ideal oil heater are: (1) good combustion with but little smoke from beginning to end of firing period; (2) efficient radiation; (3) ample capacity; (4) possibility of controlling rate of combustion; (5) low cost; (6) simple yet substantial construction; (7) parts nesting well for storage; (8) good protection of oil from rain; (9) ease of handling, filling, lighting and extinguishing. It is needless to say that the ideal heater has not yet appeared, but some of the types recently put upon the market are far ahead of the original types in meeting most of the above requirements.

We will take, for example, the Dunn (Down Draft and Center Feed) orchard heater manufactured by the American Can Co. The capacity of this heater, five or seven gallons, is ample for any freeze which is at all likely to occur. Tests of actual burning time showed that the heater would burn nine hours with all drafts open. With the proper number of heaters the amount of heat thus given off is much more than ample for any ordinary frost. The draft openings can be so reduced that the burning time can be lengthened to twenty-four hours. This heater is of substantial construction, being made of twenty-four gauge annealed steel; the bowl is pressed out of one piece and is therefore seamless, thus lessening the danger of leakage. The heater is provided with a down-draft tube. The

air is drawn down through this tube and discharges through round openings over the surface of the fuel as it recedes in burning. When the fuel has been consumed within two and one-half inches of the bottom of the pot, an additional amount of air is discharged out of the end of this tube which reaches the center of the pot, thus causing combustion of practically all of the remaining fuel. One great difficulty with the earlier types of heaters was that much unconsumed residue was left in the bottom of the heater at the end of the burning period. The amount of air admitted to the down draft tube is regulated by a dome-shaped sliding valve. A second draft opening called the "center-feed" is provided on the opposite side of the inside cover of the heater. This opening admits air into the mouth of the stack for the purpose of promoting the combustion of the gases as they rise into the stack. The rate of combustion is thus well under control. Furthermore a long collapsible stack has been developed by W. C. Scheu which can be used on this heater as well as on his own heater, the Scheu Orchard Stove. By the use of this stack the combustion can be materially increased with a corresponding decrease in smoke. By the use of the tall stack the amount of heat given off as radiant heat is also increased and this is an important factor. The Dunn heater is easy to handle, to light and to extinguish, and is well protected from rain by the umbrella cover which not only completely covers the stack, but also the draft openings in the inner cover.

Time will permit only a brief reference to the improvements which may be expected in present methods of frost protection, or to new methods which may be developed later. First we have the covering of orchards with cloth covers. Thus in one experiment going on at present in southern California, a light tobacco cloth is used to cover a lemon grove of several acres. On cold winter nights the temperature has been found to remain at four to six degrees F. higher than outside the tent covering. Other advantages are noticed in that the fruit is of much better quality inside the tent than outside, there are more summer lemons inside the tent, and the amount of wind-scarred fruit is reduced. This experiment has not, however, progressed far enough yet so that definite conclusions can be drawn as to its practicability.

Another experiment which has been tried recently is that of piping oil to various parts of the orchard and providing some form of burner which will consume the oil directly as it is fed from the pipes. This system has the following advantages: (1) it eliminates the labor of refilling the heaters when in use and it eliminates the care and depreciation of the heaters through the summer season. The practicability of this method in actual orchard practice has not, however, yet been thoroughly demonstrated.

As to oil heaters in their present form, the most needed improvements would seem to be in securing more efficient radiation together with greater simplicity in construction and less cost. The tall stack goes far toward securing more efficient radiation and it is the radiated and not the convectional heat which is most effective

in orchard heating. A large proportion of the radiated heat is intercepted by the foliage of the trees and thus gets to the place where it is most needed, while much of the convectional heat rises above the trees and is lost entirely.

Last of all, much may be done in rendering frost protection less needful by the development of varieties of citrus fruits which will be as good as any we now have and much more resistant to cold. The work of Dr. Webber, Dr. Swingle and others has already shown that this is possible and it is to be hoped that much may be done along this line in the future.

SOME PROBLEMS OF CO-OPERATIVE MARKETING.

By B. B. PRATT, *Los Angeles, California.*

No attempt will be made in this brief paper to cover the whole field of co-operation. The purposes, theory, method of operation, and the essentials for success of co-operative marketing agencies, have been clearly set forth in a number of papers in recent years. These treatises have been written by able and experienced writers and with the most of these you are all familiar. Nor is it the purpose of the writer to discuss in any detail the organization for selling at the market end. While it is true that the co-operative agency has certain features peculiar to itself in its relation to the trade, it is nevertheless true that in business method of selling the mode of operation is not widely different from that of any other type of marketing agency with an equal volume of business. The machinery of selling may consist of salaried agents where volume of business permits, or the more common brokerage channels may be utilized in the distribution of the crop. The relation of these marketing agents to the shipper on the other hand differs quite widely from the relationship of similar agents to ordinary commercial packers and shippers. A co-operative organization's most serious problems in determining how efficiently any given system of agencies may be developed or utilized, arise at the producing end. Business judgment and experience will dictate the course of the management in handling the markets in-so-far as the approval of its policies by the rank and file of the organization membership will permit.

The problems confronting the small single co-operative marketing organization are largely local in character and are not dissimilar from the difficulties which present themselves to the individual association in co-operative federations of shippers. Few of the larger questions of policy require solution by the management for the simple reason that the output is not such that the organization can hope to influence greatly the distribution of the general crop in which its growers are particularly interested, thus curtailing the effect of such combined effort of growers on the status of that particular industry in the markets of the country. This is markedly true of those crops produced in numerous and widely separated

regions of the country. The most that such an organization can hope to do is to deal in a few markets and in large part it must depend on brokerage or commission agencies for its direct market service. In this regard, therefore, the association is chiefly effective from a purely marketing standpoint in that in volume and presumably in business administration it is on a similar basis to that of the large individual grower or producing corporation. In other words, its volume is such that it can satisfactorily fill orders for products of similar grade and pack and can command the active attention for its output and a fairness of dealing from such marketing agents as are within its reach in a measure that the individual small grower could not hope to attain for his portion of the output taken alone. There are, of course, many other advantages to be gained by the associating together of such growers aside from the purely marketing feature of an industry. With these you are all familiar and they need no enumeration here.

The nature of the problems of a large co-operative body made up of a federation of co-operative societies, is quite different in their scope from those of the individual isolated organization. Here we find questions of policy presented for solution which affect the entire status of the industry with which it deals in its position before the trade of the country. This is particularly true if the industry is concentrated as in the case of the citrus industry. A few of the problems of an organization strong enough to dominate the distribution and selling of the product of an entire industry, the writer desires to briefly suggest to you in such detail as the limits of a paper of this character will permit.

No new fact is stated in the assertion that all permanently successful co-operative enterprises have had their origin in dire necessity. Such organizations, however, may develop, through integrity, good management and through influence on market conditions, to the point where the feature of necessity is somewhat lost sight of, but continue their progress uninterrupted through the force of sheer size, solid organization and efficiency. One of the problems which the writer desires to emphasize develops at this point. In the early stages conditions are such that all growers are keenly alive to the situation and keep closely informed regarding successive steps in the progress of the organization's policies. As conditions improve memory of the early features of necessity become dulled; rumor kept active by the opposition finds readier response where new questions of policy arise. This is particularly true if the policy adopted has to do with larger expenditures and serious difficulties may be in store for the management unless means are adopted to prepare the rank and file of the membership through education as to the fundamental basis of these new policies. It may be taken as axiomatic, therefore, that important new business policies, if they are to be successfully inaugurated by a large co-operative body, must in effect come from the bottom up, or in other words, must have the active support of the membership. A management which assumes that it can adopt such policies without securing this

support through education and preparation of the membership for the new steps simply because they have a sound business basis is doomed to failure. On the other hand, it should not be inferred that desirable business methods cannot be adopted simply because they meet criticisms. No important policy which such an organization may adopt will go wholly without criticism.

An organization which has taken on permanency through improvement which it may have given to the marketing of products with which it deals and which has existed over a period of successful years, is subject to marketing agitation and unrest amongst its membership whenever economic conditions are such as to lower the return to the grower close to or below the cost of production. Such an agitation developed in the citrus industry during the past winter. It is no more than natural that a material proportion of growers out of a clientele of 7,000 should not be closely informed regarding economic conditions even though such conditions are serious enough to depress all industry. Neither is it unnatural that these individuals should question the continued efficiency of their organization which has served them so well in the past, nor that they should ask whether it is not possible for their marketing machinery to so revolutionize methods as to once more raise them from the "Slough of Despond" as it did so well in the days of its origin.

It is during such periods that retail prices are compared with those received by the producer and demands arise for direct marketing to the retailer or even to the consumer himself in order that the producer may secure a larger proportion of the consumer's dollar. Desirable as is the attainment of this result, it may be said that the basis on which such proposals are made is for the most part fallacious and the evidence presented in support of such methods of marketing is incomplete and unsound. This evidence usually takes the form of a comparison of retail prices with those the grower secures, resulting in the conclusion that retail prices do not follow delivered prices and are maintained at artificial high levels. Such reports usually are made on desirable grades handled by the better class of dealers and no report is made on the service cost or on the prices maintained by those dealers performing a cheaper class of service. Time does not permit of detailed discussion but it may be said that definite detailed investigation has shown that retail prices in general do follow fluctuations in wholesale prices. Prices charged by different retailers for the same class of fruit products will always vary widely. These prices are a combination of the amounts charged for the fruit itself and that charged for the type of service performed. The cost of delivering food to one hundred million consumers depends on the varying demands of different groups of consumers. These service demands are wholly beyond the control of the producer and the dealer and are the affairs of the consumer alone. The overhead cost of a system capable of reaching 300,000 retailers is beyond the reach of an industry handling one class of produce, particularly when that product is subject to climatic disaster. Such an overhead can be borne only when

spread over a wide variety of merchandise or when the product handled is a non-perishable which caters only to one class of trade and whose production can be regulated and is not dependent on reaching the whole consuming population for profitable disposal.

In view of the above facts the co-operative fruit marketing organization finds its chief opportunity for improving markets in fair dealing, even distribution, and a high standard of grade, pack and keeping quality. With these conditions it can stimulate consumption through advertising, and through better service to the dealers, can encourage lower margins and better service to the consumer. This means better prices to the consumer and at the same time a higher net return to the grower. So long as the trade entertains any doubt of the honesty and quality of the pack or of the average keeping quality of the brands offered, just so long will margins be wide to cover the risk. With a product prepared in such a manner as to preserve its inherent merchandising quality, margins will automatically be reduced as a result of competition.

With a large co-operative organization composed of numerous independent units, this question of standardization is one of the most difficult problems it has to solve. Few growers personally interested in the fruit are capable of judging of its grade. To those officers in daily contact with the market problems the need for uniform standards is self-evident. The growers in a locality, on the other hand, unfamiliar with the relative merit of their pack as compared with that of other localities, may actually resent suggestions for the improvement of their condition. It is not uncommon to find in territories covered by such an organization, localities kept in financial distress because of the character of the methods pursued by the management of their unit or units of the system. Because of this fact the value of the marketing system is often nullified and the system thereby weakened by conditions almost wholly beyond its control. Where such conditions prevail the membership lacks stability.

No co-operative organization can be fundamentally strong without a fairly stable membership. This question then becomes one of the problems of marketing the crop of an industry. Successful marketing means the removal of the crop from speculation, and co-operation abolishes personal profits from the marketing business. It is only natural then that interests dependent on these elements for their livelihood should be constantly circulating rumors antagonistic to the growers' organization. These rumors take the form of deliberate untruths or half-facts. It is not strange that growers are more influenced by intimations that their business is not being handled properly than to statements of fact showing efficiency. The latter are only confirmation that they are getting that for which they organized; the former strike at their feeling of security and their personal prosperity. A class of membership difficulty almost beyond the influence of an organization's management is that engendered by personal antagonism and dislike. To secure a co-operator in a new member is more important than the addition of

volume to an organization already strong. On the other hand, stability of membership means stability of volume.

In summary we may say that the big problem in co-operative marketing is one of co-ordinating all the elements which affect the merchandizing value of the organization's output. These elements have to do with volume, distribution and character of the product and its method of preparation as well as with the actual system of selling agency used and its administration. There is no more human an institution in existence than a co-operative marketing organization.

PRESENT STATUS OF THE NUT INDUSTRY IN CALIFORNIA.

BY R. H. TAYLOR, *University of California, Berkeley, California.*

While nuts of one kind or another are found growing in nearly all fruit sections of the United States, California has practically all of them growing successfully within her borders. Those of commercial importance are relatively few, and it is with these only that this paper deals, viz., the Persian walnut, almond, pecan, chestnut, filbert and pistache. Of these the walnut and almond are thoroughly established as a commercial crop in this state, while the pecan, chestnut, filbert and pistache, are still in the experimental stage.

Up to the present, California has had a practical monopoly of the domestic production of Persian walnuts and almonds and this will help explain the reason for the early development of these two industries.

EXTENT OF PRODUCTION.

A brief consideration of the extent of production of nuts in the United States together with the imports from foreign countries will enable us more clearly to understand their present status. The following figures are compiled from the United States census and other government reports for 1909:

Production of all nuts in U. S.—62,328,010 lbs., valued at \$4,447,173.
 Production of all nuts in Cal.—28,378,115 lbs., valued at \$2,960,000.
 Imports of all nuts into U. S. valued at \$8,549,997.
 Almonds produced in U. S.—6,793,539 lbs., valued at \$711,970.
 Almonds produced in Cal.—6,692,513 lbs., valued at \$700,304.
 Almonds imported—10,658,686 lbs. (Normal—15,000,000.)
 Walnuts produced in U. S.—22,026,524 lbs., valued at \$2,297,336.
 Walnuts produced in Cal.—21,432,266 lbs., valued at \$2,247,193.
 Walnuts imported—27,214,793 lbs.
 Pecans produced in U. S.—9,890,769 lbs., valued at \$971,596
 Pecans imported—1,480,289 lbs.
 Filberts and hazel-nuts imported—8,750,526 lbs.

California produces practically no pecans (only .45 per cent of the domestic product), yet in spite of that she produced in 1909, 45.53 per cent of all the nuts of all kinds grown in the United States. This figure is as high as it is because California produced 98.51 per cent of all the almonds and 96.4 per cent of the Persian walnuts grown in the United States.

Of the entire supply of all nuts both domestic and imported for 1909, the latter were worth 65.78 per cent of the total value. Normal imports are between three and five times as many almonds, and between two and three times as many Persian walnuts as are produced in this country at the present time.

IMPORT DUTIES.

The duty on shelled almonds was dropped by the Underwood Tariff of 1913, from six cents a pound to four cents, and on unshelled almonds, from four cents to three cents. On Persian walnuts and filberts, the duty was reduced from three cents a pound to two cents for unshelled, and from five cents to three cents for shelled. On pecans the duty of one cent per pound still stands.

COST OF PRODUCTION.

Figures on cost of production are necessarily of uncertain value because no systematic work has yet been done to determine the actual costs under the varying conditions which at present surround the industry. Generally, however, the cost of Persian walnut production ranges from \$10 to \$50 per acre. With almonds, the cost will be between \$20 to \$50 per acre, interest and taxes not included. With an average annual production of almonds of about 800 pounds per acre, and selling at twelve to fourteen cents a pound, the gross returns will range from \$84 to \$98 per acre. At these figures the import duties are necessary to enable our growers to compete with the cheap European labor which produces the foreign crop.

FUTURE PROBLEMS.

In the last two or three years another problem has appeared which must be reckoned with in the near future. New plantings have increased so rapidly in the case of almonds that there appears to be danger of over-production. The inevitable result will be the drop in price to a figure at which the grower can not afford to produce the crop. Just a few weeks ago the writer was requested by the manager of the California Almond Growers' Exchange, which handles over 75 per cent of the crop of the state, to discourage the planting of more almonds for the present. Markets for nuts can not be developed rapidly enough to take care of the increasing supply. Sales have increased very greatly in the past few years, and will continue to do so. Increased consumption of luxuries, however, can be developed only slowly, and as long as nuts are considered luxuries, this will be the case with them.

One means of increasing both the demand and supply is to lower the cost of production and the selling price by a system of care, which shall mean handling the orchards with more thought for the future of the tree and the crop than has held in the past. Cultural requirements are comparatively easily supplied where due diligence is given to choice of location, soil, etc. Thousands of acres unsuited to the nut intended to be grown, have been sold to uninformed persons either before or after planting. At the present time there are many orchards of nut trees that are either doing poorly or are dying on such lands.

Before any plantings are made, the prospective planter should know the requirements of the nut to be grown.

ALMOND REQUIREMENTS—LOCATION.

The almond is the first of our orchard fruits to bloom in the spring, thus rendering it susceptible to late spring frosts. In choosing a location for almonds, special care must be exercised to avoid frost pockets—air drainage is essential. The higher lands along stream banks are generally the best because they allow the drainage of the cold air to lower levels, and also because such soils are generally lighter and better drained than those further away from the streams.

SOIL AND MOISTURE.

The almond prefers a quite uniform, medium loam soil to a depth of about twelve feet free from hardpan or other impervious layers, and also free from sand or gravel layers. It will not endure standing water around its roots for any length of time, especially during the growing season. Lack of proper drainage will very quickly cause sour sap and kindred ills and will cause the death of many of the roots. On the other hand, layers of sand or gravel which cause excessive drainage of the moisture from the soil also allow the soil to dry out, and many of the feeding roots to die. This results in a tendency for the top to die back, and for the tree to set weak fruit buds which are very easily injured by frost the following spring. Being large growers and heavy feeders, experience has shown that the trees should be planted at least thirty feet apart for best results.

ROOTSTOCKS.

Unfavorable conditions may be partially remedied by choice of rootstock to suit the soil and moisture conditions. For the best almond soils which are deep, uniform in texture, and well drained, the almond root is the best. Where the soil is inclined to be shallow, leachy or irregular in texture at different depths, the peach root is probably best. If summer irrigation is necessary, the peach root will be the one to use. The Myrobalan plum has been recommended by some for use in heavy soils, but it does not make the best kind of a union and old trees on this stock are not as hardy nor do they bear anywhere near the amount of fruit borne by trees of the same age on other roots in the same orchards.

PLANTING.

The pollination question is still unsettled. There is much apparently conflicting evidence on this point. It appears, however, that some imperfect pollination is the result of unfavorable weather conditions rather than self-sterility. In starting orchards, it is advisable to interplant, using two or three varieties. By planting two rows of each variety alternately, the best results will be obtained and harvesting operations will not be interfered with. By using several varieties, the harvesting season can be prolonged considerably and a heavy rush avoided.

CULTIVATION AND NUTRITION.

Proper and frequent cultivation is essential to enable the tree to grow through a long season. The almond is the first tree to come out in the spring and the last one to go dormant in the fall under favorable conditions. It is also a heavy consumer of plant food and moisture. Where the moisture becomes deficient before the growing season is over, the tree is unable to properly mature the very large number of fruit buds which normally set. Many comparative observations have been made to observe the effect of the trees becoming prematurely dormant on the crop the following season. Other conditions being equal, the invariable result has been that the trees which continued their normal growth until the fall frosts were able to withstand a greater degree of frost, and other unfavorable conditions in the spring, and set a heavier crop of nuts. The effect of trees going prematurely dormant from year to year seems to be cumulative, so that it may take several years to bring trees back to their normal strength.

IRRIGATION.

Irrigation should be done thoroughly where done at all, and then all the moisture possible should be retained by thorough and regular cultivation. Water should not be applied between blooming and the time that the fruit is well set on the trees and of pretty good size. Neither should water be applied between the time the nuts commence to ripen and the time of harvesting. If water is applied in an effort to revive trees which have approached premature dormancy too far, the tendency is to induce a new start of wood growth rather than to put that energy into setting strong fruit buds. In extreme cases the trees come into bloom in the fall after the application of the water. Over-application of irrigation water in the summer is quite likely to induce sour sap. Perfect drainage is absolutely essential. Winter irrigation is much preferable where the soil is deep and heavy enough to retain moisture for use throughout the summer.

PRUNING.

Pruning after the first two to four years, as at present practiced, consists largely in the removal of watersprouts, dead and interfering branches. The nature of the crop and the methods employed in harvesting it, make it unnecessary to keep the tree comparatively low as is necessary with fruits which must be picked by hand, such as the peach, apple, pear, etc. Irregular pruning is commonly practiced to the great detriment of both tree and crop. A moderate pruning each year tends to keep the tree growing normally and does not induce the excessive growth of watersprouts that the irregular pruning does. This watery growth weakens the set of fruit buds.

The almond is naturally a long-lived tree and will grow and bear good crops when past forty and fifty years old, provided decay is kept out of the heart of the tree. This is not difficult to do if large wounds are properly cared for so as to encourage rapid healing.

HARVESTING.

Harvesting is done when the hulls have split well open, exposing the nut inside, by knocking the hulls, with the nuts in them, from the trees with poles. These drop on large canvas sheets spread on the ground beneath the tree. They are emptied into lug boxes and hauled to the huller where they are hulled by machinery. The nuts are then spread on trays to dry in the hot sun. They will be dried sufficiently when the meats break without bending.

BLEACHING.

If the nuts are intended for the whole nut trade, they are next bleached to make the dark nuts lighter and more attractive in appearance. They are first either sprayed lightly with water, or what is far better, steamed for a short time so as to moisten only the shell, and are then run into a closed room or bleaching house where the fumes of burning sulphur will do the bleaching in from ten to thirty minutes. Care must be exercised to see that no moisture gets to the kernel for the fumes will penetrate the meat and injure the flavor. Nuts improperly bleached do not keep well and soon become rancid. Bleached nuts do not germinate as well as unbleached ones if it is at all over-done.

If the public could be taught to use unbleached almonds, it would eventually be better satisfied because of better and more uniform flavor and keeping qualities. Some varieties are naturally lighter in color than others and these are gradually gaining in preference over the darker shelled varieties. Weather conditions at time of ripening have a great deal to do with the color of the shells. Damp or foggy weather at this time will cause them to darken very materially. Hot, dry weather ripens the nuts quickly and they may be harvested and dried before they have much opportunity to darken.

CRACKING.

If the nuts are to be cracked for the meats, sulphuring, of course, would not be necessary. In this case the nuts and shells are allowed to become thoroughly hard and dry, and then they are run through the cracking machine. Up to the present time no one has been able to devise a cracker that will shell Jordan almonds without breaking a large proportion of the meats. This variety has an exceedingly hard shell and an especially fine flavored meat. The hard shell, however, has prevented the Californian, under the handicap of high price labor for hand cracking, from competing with the Spanish producer with his cheap labor. One reason for the small acreage of Jordans is therefore clear. At the present time most of the Nonpareil crop is cracked for confectioners who want the meats only, and desire a plump, smooth, uniform meat, easily bleached and of a good flavor.

VARIETIES.

The varieties at present grown are nearly all of local origin, the European varieties doing much more poorly as a rule. The Hatch varieties (Nonpareil, I. X. L. and Ne Plus Ultra) are by far the most popular. Then comes the Drake, and after that the Texas and Languedoc. The three Hatch varieties are early bloomers and also the first to ripen. The latter is a very strong point in their favor. Some varieties are very good in themselves but are so late in ripening as to distinctly reduce their value. The late ripening varieties are liable to be caught by the early fall rains. The earliest blooming varieties are objectionable because of the danger from late spring frosts. Unfortunately, however, the best varieties are not the late blooming ones.

PESTS.

Like other orchard trees, the almond has its insect pests and diseases. Of the insect pests, the worst is undoubtedly the red spider, of which there are two distinct kinds, the brown mite, (*Bryobia pratensis*), and the yellow mite (*Tetranychus bimaculatus*). The former lives on the tree the entire year and works nearly all summer. The latter lives in the ground and other plants during the winter and spring and crawls onto the almond about the middle of May, or after. The brown mite may be very successfully controlled by the late winter spray with lime-sulphur just before the buds open. The yellow mite can be controlled by means of dry or liquid sulphur sprays just as soon as the pest appears on the trees. The liquid sprays are much more positive and satisfactory in every way and they are gradually replacing the dust sulphur, which was formerly the only one used. Where the red spider or mite is not controlled, the leaves often drop in mid-summer, sometimes before the crop is harvested. The evil effects of such conditions are obvious.

DISEASES.

Of the diseases, the root knot is probably the most widely prevalent. Control must begin with planting healthy trees with clean roots. After infection takes place, control measures can hardly do more than hold the disease in check. In some cases, complete removal of large knots at the crown followed by painting with bordeaux paste will lengthen the life of the tree very materially.

Armillaria, or oak fungus, is found in many districts though generally in rather small spots at the present time. The almond is one of the most susceptible to this disease. The chief means of control at present lies in cutting out trees from and around infected areas to prevent its slow but steady onward movement.

Shot hole fungus does appreciable damage in years of late spring rains and continued damp weather. As a rule it is not serious, however.

Sour sap is sometimes bad after late spring rains followed very quickly by warm growing weather. This condition is much worse in heavy, poorly-drained soils because of the almond's natural intolerance of standing water around its roots.

THE PERSIAN WALNUT—SOILS.

The Persian walnut requires different conditions in many ways from the almond. Instead of a light soil, it much prefers a comparatively heavy soil though in either case it must be deep and well drained. Instead of thriving under hot dry weather this walnut prefers somewhat cooler conditions where sunburn will not be so bad. It is a large grower and heavy feeder, using large amounts of water in a season. The ideal soil, therefore, is a fairly heavy soil, uniform to a depth of at least twelve feet, free from an excessively fluctuating water table, and well drained. The naturally late blooming habit of the walnut renders the consideration of frost unnecessary except at higher altitudes and in places where the spring frosts continue very late.

ROOTSTOCKS.

The Persian walnut industry in Southern California and along the coast has been largely a seedling industry, and now that propagation of definite varieties is being undertaken on a larger scale, the subject of rootstocks has become a very important one. The Persian walnut root is very subject to unfavorable moisture conditions and to some diseases such as *armillaria*, whereas the California black walnut and the hybrid roots are much more resistant. The California black and the Royal hybrid (California black x eastern black) will live under soil moisture conditions which would kill the Persian or Paradox hybrid (Persian x black) walnut. For this reason they have been widely used for stocks. There is not sufficient evidence yet at hand to say that, in the long run, the hybrid roots make sufficiently better rootstocks to pay for the added difficulty in getting true first generation hybrids. The straight California

black walnut root is still very popular and deservedly so. In the central and northern parts of the state, and especially in the valleys away from the coast, the Persian root is very little used. By using a California black root grafted high to Persian a great deal of sunburn of the trunk is avoided.

VARIETIES.

For interior situations where sunburn is bad, this is liable to extend to the nuts themselves if the tree is of the type which bears nuts on the outside of the tree unprotected, or largely so, from the hot sun. Some varieties, such as the Eureka, bear their nuts on the inside of the tree, or shaded by the leaves where borne on the outside, so that sunburn is reduced to a minimum. By a judicious choice of varieties, the area, where successful walnut culture is practiced, has been greatly enlarged and will be still further.

These conditions have resulted in the development of a considerable area to Persian walnut culture in California which it was previously supposed was not fitted for it. The prospects are that in the future the Southern California will have real competition in Northern California, though the varieties which will be grown in the two districts will undoubtedly be largely different.

The Persian walnut acreage is increasing much more slowly than the almond acreage because of the much greater time necessary to bring the trees into bearing, and also because of the greater difficulties and cost of getting the plantation started.

WALNUT BLIGHT.

The limiting factor in Southern California, especially, is walnut blight, for which no real control methods have yet been found. The selection of late leafing and blooming varieties helps to a certain extent, but in some years even these varieties do not seem to avoid it.

THE PECAN.

The status of the pecan in California is still very uncertain. Trees can be found growing in various parts of the state though for the most part they are seedling trees of unknown parentage. There are, however, a few trees which give indications of what can be expected by a judicious selection of varieties, etc. Before this can be fairly done, a much greater amount of trial and experimental work must be assiduously followed out.

The soil requirements which are similar to those of the Persian walnut, are readily found here as has been demonstrated by the fine, thrifty growth and good condition of old trees found growing along the roadsides.

If we consider only the high class nut of the good size, flavor and cracking qualities of many of the standard varieties, the pecan is considered to be the best nut on the market, and when the price comes down to a reasonable figure there is no reason why the present consumption should not increase many times over.

Because the pecan is not native to California, as it is to a large

part of the South, we could not hope to compete with natural groves and cheap labor; but in the large sized named varieties of good quality, there is no apparent reason why some districts could not do well with this crop.

THE CHESTNUT.

The chestnut up to the present time has never been given a fair trial in this state. It is possible that with the forests of chestnuts in their natural habitat in the eastern states being speedily killed by the chestnut bark disease, that some of the trade in chestnuts might be transferred to this part of the country. The disease can be kept out by quarantine with no fear of its coming from the East by natural means, because of the great impassable barriers of mountains and deserts.

Sufficient trees may be found growing in the state to indicate that climate, soil and moisture conditions favor the growth of good strong healthy trees. Here again we still have the problem before us of choosing the right kind and varieties which will be adapted to commercial production. This industry at best must grow slowly, but there is no doubt that it should be tried in many places where at present no trees of value are being grown. Many of our mountain counties appear to be well adapted to this tree.

THE FILBERT OR HAZEL-NUT.

The filbert, or cob-nut, or hazel-nut, belonging to the genus *Corylus*, is at the present time of no considerable economic import in the United States. Oregon is doing something with it in an experimental way at least. The hazel is native to California and it is possible that this wild nut may be made to become of greater value if varieties can be found or developed which will produce with greater regularity. The European varieties are subject to a fungous disease in the East which probably accounts for failures in making the industry profitable there. Conditions here are favorable for naturally holding such a disease in check.

THE PISTACHE.

The pistache nut, used so commonly in confectionery and flavoring, is a comparatively new nut in California. There are plantings in both northern and southern California that show the possibilities of production. It is too early yet to predict to what extent the industry will expand, though present conditions are very favorable.

CONCLUSION.

With such possibilities for the development of new lines of nut culture and the enlarging of old ones by careful, sane methods of reducing the cost of producing and marketing, and the development of varieties that will bear larger crops of better quality, California has a large field of usefulness and a responsibility which she must not shirk.

**THE SUMMER TRAVELING PRACTICE COURSE AS A MEANS OF
TEACHING HORTICULTURE.**

By J. E. COIT, *University of California, Berkeley, California.*

(This address is published in the Cornell Countryman for October, 1915.)

ANNUAL MEETING AT COLUMBUS, OHIO.**1915****TUESDAY, DECEMBER 28, 9:30 A. M.**

Owing to the absence of President Howard the meeting was called to order by Vice-President Crow. President Howard arrived and presided after the first address was given. The program as published was followed as closely as possible.

THE PERSIAN WALNUT IN PENNSYLVANIA.

By F. N. FAGAN, *Experiment Station, State College, Pa.*

This subject may come as a surprise to many members of the Society for Horticultural Science. Throughout Pennsylvania we find a large number of old Persian walnut trees. The majority of these trees are seedlings. They show a great deal of variation in shape of nut, flavor of kernel, color of kernel, thickness of outside husk and size of the mature nut. They also show different degrees of hardiness, many trees being killed and others injured by winter conditions. The winter of 1911-12 was quite severe in regard to low temperature and drying winds. Many trees, however, withstood this winter and showed no injury in the spring of 1912 and have been in a healthy condition ever since.

The interest in nut culture throughout our state is increasing and especially in the Persian walnut. This condition, no doubt, is stimulated by the advertisements of nurserymen selling walnut stock.

The Experiment Station in the past three years has been besieged by many inquirers, asking for information relative to varieties, soils, and where trees could be secured.

A publicity campaign was started by our newspapers of the state, asking for information as to the location of any bearing Persian walnut trees within the state. We have been greatly surprised in the number of trees reported. Many of the trees have been visited by representatives of the College and Experiment Station. About 2000 trees have been reported including several good sized groves which are tabulated as follows:

In Erie County, two groves have been reported; one has 250 trees 14 years old and planted 50 x 50 feet. These trees are seedlings of Pomeroy. The other grove has 100 three-year-old trees.

In Berks County there is one five-acre grove about 22 years old of budded stock received from France.

In Bucks County is one grove of 600 trees eight years old. No information has been received in regard to the varieties or source of trees. One grove of 40 trees about twenty-five years old has been in bearing for a number of years.

Throughout the state we find the trees on both mountain and valley land. They are scattered in 27 counties.

The yields that have been reported vary from one or two bushels every other year to regular croppers producing as high as nine bushels a year on the average.

From the information that we have been able to secure through inspection and correspondence, we feel hopeful that from the seedling trees we will be able to develop varieties for propagation purposes which at least will be desirable for the home planting in practically all of our counties. Possibly in our more favored section along Lake Erie and in our southeastern counties, varieties may be produced that can be used in more or less of a commercial way.

The subject of stock upon which the Persian walnut should be worked is undoubtedly in the experimental stage in our state. The black walnut is being used but it is not a vigorous grower. The Persian walnut seedling is a more rapid grower, but possibly not quite so hardy. The common Japanese walnut is a very thrifty grower and seems to be quite hardy. Thus it may be desirable to use it in experimental work. To be sure, our eastern states can draw upon the hybrid nuts of California for their stock, if desirable.

We expect to continue the work with the Persian walnut, but it is needless to say that it will take years before definite information is received from experimental work.

(This address was illustrated with lantern slides showing many of the walnut trees growing in Pennsylvania.)

THE TWO GROUPS OF VARIETIES OF THE HICORA PECAN AND THEIR RELATION TO SELF-STERILITY.

By H. P. STUCKEY, *Georgia Experiment Station, Experiment, Ga.*

For a number of years we have been collecting data on the behavior of a considerable number of varieties of pecans at the Georgia Experiment Station. During this time we have received frequent notices from various sections of the pecan belt, of isolated single trees or of isolated small groups of trees of a single variety being shy bearers, or not bearing at all, though past the usual bearing age for that particular variety. This raised the question of whether or not some of the varieties of pecans were not wholly or partially self-sterile.

THE TWO GROUPS OF VARIETIES.

In making our phenological notes on twenty-five varieties grown in the variety plat, we observed that the varieties could be divided into two distinct groups based on the floral characters of the catkins of the staminate flowers. In group I, the catkins of staminate flowers are large and the individual flowers of the catkins are shielded by rather small and inconspicuous bracts. In group II, the catkins of staminate flowers are narrower and often longer, while the bracts shielding the individual flowers are long and conspicuous. However, the two most important differences between these two groups, from an economic viewpoint, are the difference in the viability of the pollen, and the difference between the time the pollen is shed and the time the pistillate flowers become receptive.

Samples of pollen from each variety of the two groups were collected and germination tests made. It was found that the pollen of group II was almost three times as viable as that of group I. The following table gives the results of the germination tests in detail:

GROUP I.

Variety.	Per cent of Pollen Germinated.
Big Triumph.....	5
Centennial	10
Jerome	12
Mantura	1
Mobile	15
Nelson	10
Pabst	12
Robson	12
Randal	15
Rome	8
San Saba.....	2
Washington	1

GROUP II.

Variety.	Per cent of Pollen Germinated.
Appomattox	15
Atlanta	40
Bradley	35
Curtis	40
Frotscher	40
Moneymaker	20
Pan American.....	40
President	15
Stuart	20
Teche	50
Van Deman.....	5
Young	15

On May 11, the pollen of Robson and Big Triumph that was gathered May 3, was again tested. Pollen from both of these varieties germinated. Germination tests were made of the pollen of several of the varieties twenty days after it was gathered and brought into the laboratory, but none of it germinated.

But it is in the time of the shedding of the pollen that, perhaps, the most important of the differences between the two groups is to be found. Varieties of group I shed their pollen at about the same time that the pistillate flowers become receptive. In group II we find that the varieties shed their pollen after the pistillate flowers are receptive, some of them shedding their pollen as late as thirteen days after the pistillate flower reaches the receptive stage.

A large number of terminals of several varieties were bagged with a heavy grade of cheese cloth. In some of the bags all the catkins of staminate flowers were cut out; in others both staminate and pistillate flowers were allowed to remain. Accurate records of the dates the pollen began to shed, the dates the pistillate flowers became receptive, and the type or size of the catkins, were kept for all varieties. The following table gives the results:

GROUP I.

Variety.	Date Pistillate Flower Receptive.	Date Pollen Began to Shed.	Size of Catkin.
Alley	May 1	May 1	Large
Big Triumph.....	" "	" "	"
Centennial	April 30	" "	"
Mobile	May 1	" "	"
Mantura	" "	April 30	"
Nelson	April 30	" 28	"
Pabst	" "	May 1	"
Randal	May 1	" "	"
Rome	April 30	April 30	"
Robson	" "	May 1	"
San Saba.....	" "	" 2	"
Washington	" 29	April 27	"

GROUP II.

Variety.	Date Pistillate Flower Receptive.	Date Pollen Began to Shed.	Size of Catkin.
Atlanta	May 1	May 10	Small
Appomattox	April 30	" 5	"
Bradley	" "	" 9	"
Curtis	" "	" 13	"
Frotscher	" "	" 10	"
Moneymaker	" "	" 6	"
Pan American.....	" "	" 9	"
President	" "	" "	"
Russell	" "	" 6	"
Stuart	" "	" "	"
Van Deman.....	" "	" 9	"
Teche	" "	" 8	"
Young	" "	" 9	"

Unfortunately, the cloth from which we made our bags was too heavy or thick and excluded so much air and light that it prevented normal fertilization where the catkins were left in the bags, or even where hand pollination was practiced. Under these conditions very few normal or mature nuts were produced in any of the bags regardless of the kind of pollen applied.

From the foregoing data the relation of the two groups of varieties to self-sterility is obvious. The interval between the receptive stage of the stigmas of the pistillate flowers and the shedding of the pollen of the varieties of group II, shows the necessity for including in all pecan plantings some of the early staminate blooming varieties to serve as pollinators. This point is made clear by noting the time of the pollen shedding of the Curtis variety. On May 12 the stigmas of the pistillate flowers of the Curtis variety had completely dried and the young nuts had begun to develop although no pollen from the staminate flowers of this variety had begun to shed, thus showing that the pistillate flowers had already been fertilized by earlier blooming varieties.

Our work is not conclusive, neither is it complete, yet we feel that the observance of the results already obtained will aid towards preventing much of the poor bearing of pecans throughout the pecan belt.

CULTURAL METHODS IN BEARING ORCHARDS.

By J. P. STEWART, *Experiment Station, State College, Pa.*

(This address will be published as a bulletin of the Pennsylvania Agricultural Experiment Station.)

ORCHARD MANAGEMENT INVESTIGATIONS.

By JOSEPH OSKAMP, *Purdue University, Lafayette, Indiana.*

I wish to present briefly the outline of an experiment in orchard soil management in Indiana. Not that this is by any means a new problem for research, but inasmuch as the underlying principles which govern it have been little understood and largely built upon theory, there are still many things which lack adequate explanation. We have heard that certain cultural methods have been attended with greater success in apple growing than others, but definite statements backed up by convincing experimental evidence as to why these results were achieved, have not been so readily forthcoming. Therefore, I may say that it has been our especial ideal (aside from testing out methods of management under Indiana conditions) to be able to answer why such differences are apparent and with a reasonable array of data to substantiate arguments.

This particular piece of work has now progressed five years and while some very interesting data have accumulated we do not feel justified at this time in offering results. Many are too prone to look upon statements made in public as definitely established facts, no matter if advanced as only tentative conclusions.

In bringing this outline before you I trust we may be mutually helpful. New ideas, criticisms and suggestions are invited and will be gladly received.

The experimental plots are located on a glaciated, rough, river bluff, upland soil in southern Indiana. The rocks of the region are limestone which outcrop on the steeper hillsides. Mechanical analysis shows the soil to be a clay silt. The soil is of very moderate fertility, 25 to 30 bushels of corn and 12 to 15 bushels of wheat being possible during favorable seasons without fertilizer. But being clay it holds the moisture exceedingly well if any attempt is made to conserve it.

The experiment is laid off in plots of two and three acres in extent. The plots are laid out as follows:

- A: Clean cultivation with rye cover crop, fifteen years.
- B: Clean culture with cover crop five years, followed by ten years in grass.
- C: Grass cut once or twice a year and allowed to lie where it falls, supplemented by an adequate straw mulch.
- D: Grass cut once or twice a year and allowed to lie where it falls. No additional mulch.
- E: Grass cut and piled about trees for five years, and then supplemented with straw for the last ten.
- F: Grass cut once or twice a year and raked up about the trees as a mulch. No additional mulch.

A system of continuous clean tillage without a cover crop has not been included in this plan for two good reasons. In view of past experience both experimental and practical, this system of orchard soil management would hardly be countenanced today, for reasons with which you are all acquainted. Then the nature of the soil and the topography of the land would positively not admit of such a practice in this case.

Likewise, a system whereby the grass is cut and hauled off for hay has not been deemed worthy of trial.

Rye has been chosen as a cover crop deliberately and with intent. It is the most universally sown crop as an orchard cover in our state, and as our cover crop experiments show it is a very satisfactory one for this purpose. It also eliminates from consideration a most elusive and variable factor. It is a non-legume and results will not be confused with the possibilities that a legume might entail with its own peculiar effect on the nitrogen and on the bacterial population of the soil.

In order that we may satisfactorily interpret the activities of the trees as influenced by methods of soil culture, it becomes necessary to have some measure of these activities and to know what changes are being wrought in the soil.

As an index of the vegetative status of the tree we have chosen circumference increment as being simple and yet accurate if taken at a fixed point on the trunk. It would seem equally as good as terminal extension or leaf measurements. Circumference measurements are taken annually and at such additional times as our other data seem to indicate important.

Studies of root growth are made possible by the planting of interplants which can be removed from time to time for study.

Of course, fruitfulness is the ultimate arbiter of the superiority of one method of culture over another. Under this head is included bearing age of tree, size, yield, color and quality of fruit.

Rather complete phenological and meteorological records are kept because of their intimate relations to other factors.

The initial soil investigations consisted of complete mechanical and chemical analyses so that future changes in these respects can be noted. Changes in the chemical and physical constitution of the soil under different methods of culture will probably occur and these in turn must influence the tree.

Soil sample stations are located throughout the plots in such a manner as to secure representative samples. In addition a similar number of plot samples is taken. The station samples in mulch plots are secured beneath the mulch about a foot from its outer edge or an equivalent distance from trees not mulched, while the so-called plot samples are taken at a point equidistant between two trees. We thus have a knowledge of conditions beneath the mulch and in close proximity to the tree roots and at the same time at a more remote point representing adjacent conditions.

All samples are taken with sufficient frequency throughout the season so that an intimate knowledge of the environment under which the tree is living is obtained. The soil factors of which we are keeping records and making determinations during each year may be grouped under four heads:

1. Soil moisture.
2. Humus and organic matter.
3. Bacterial activity.
4. Soil temperatures.

These factors are important by themselves and yet intimately related to each other.

Probably of first moment is soil moisture for upon this the plant is dependent for its welfare. And we find a great divergence in soil moisture under these different treatments, as much as 11 per cent in some cases.

Humus and organic matter count for much and are receiving due attention. They stimulate all the desirable functions of the soil and these in turn act upon the tree. It is hoped light may be shed on the weight that can be accorded to humus as a factor in tree growth and fruitfulness.

An investigation which attempts to explain the response of the tree to soil environment would not be complete without a study of the bacterial population of the soil because of the close association of these micro-organisms with moisture, humus temperature and aeration, and because they are responsible for some of the most important processes which go on in the soil, nitrification, ammonification, and nitrogen fixation.

Without going into detail here it will be sufficient to say that the numerical strength of the soil organisms are obtained by making

plate cultures from greatly diluted soil solutions which are incubated for a certain time at optimum temperature and counts made.

As an indication of the bacterial activities of the soil, its nitrifying, ammonifying and nitrogen fixing powers are tested. The method is essentially a measure of the production of these processes of nitrification, ammonification and nitrogen fixation in a suitable solution by the organisms present in a known sample of soil.

Closely related to moisture, humus and bacteria, is soil temperature. The important offices which it performs have been much speculated upon. Data bearing upon actual temperature conditions existing in the field under different cultural systems for any significant period of time, have been lacking.

A continuous record of soil temperatures is being kept by means of thermographs which record automatically. These instruments consist of a cylindrical drum revolved by an eight-day clock. The temperatures are traced upon the drum by a pen connected to an ether disc and this in turn to an ether thermometer bulb in the soil. In this way true diurnal and annual fluctuations in temperature are arrived at. It has been shown in this connection* that tillage with cover crop exhibits extreme diurnal and annual fluctuations; that straw mulch tends to equalize these fluctuations as does a grass crop, though in less degree.

It is thus hoped, by scrutinizing with an experimental attitude the various elements involved which seem to be most potent, to be able to explain our ultimate findings.

ORCHARD ECONOMICS.

By M. W. RICHARDS, *Experiment Station, Lafayette, Indiana.*

Five years ago the horticultural department of the Purdue University Experiment Station inaugurated a system of community demonstration orchards. The objects of this scheme were three-fold: First, to demonstrate to the farmers of the surrounding territory that they were overlooking a very profitable portion of their farms when they neglected their orchards; second, to educate them to better orchard management methods by ocular demonstrations; and third, to gather data on farm orchard management costs.

Neglected farm orchards were selected in ten representative sections of the state. The plantations varied in size from two to forty acres. An agreement was entered into with the owner whereby he obligated himself to care for the orchard according to the directions given by the representative from the Experiment Station. The owner agreed to furnish all necessary tools, materials, and labor, and to leave a specified number of trees uncared for as a check plot. He also promised to make full and complete reports on all labor, material and equipment expenses, as well as on all returns from the

* Oskamp, Joseph. Soil temperatures as influenced by cultural methods; *Journal of Agricultural Research*, Vol. V, No. 4.

orchard. The Experiment Station agreed to give the project personal supervision and to instruct the owner in the various branches of orchard management. From the outset the educational and demonstrational objects have been accomplished. Each orchard is a center of renewed horticultural interest. In one community alone the sales of lime-sulphur increased in two years from one barrel to three carloads per season.

The statistical data collected in this work have been very interesting. For the purposes of this paper, however, it has been deemed advisable to limit the discussion to the management costs reported from one representative orchard.

The orchard selected is located in the southwestern portion of the state on the bluffs of the White river. The region is especially well adapted to orcharding. The soil is a sandy loam underlain by a yellow clay sub-soil. The entire area is deeply underlain with soft coal deposits. Land and atmospheric drainage are excellent. Markets abound on every side because of the coal and oil industries.

The demonstration orchard is ten acres in extent and was a side line to a 100-acre hill grain farm. The trees are twenty-one years old. The varieties are as follows: Arkansas Black, White Pippin, Clayton, Stark, Grimes, Winesap, Rome Beauty and Ben Davis. All of these varieties thrive in this section although the Stark and Clayton are especially susceptible to apple blotch. This disease and the codling moth had always taken possession of the crop in past years. In the spring of 1911 the owner was induced to sign a demonstration orchard agreement. Since that date he has followed instructions and has reported very carefully on his management costs. The following table summarizes these costs.

MANAGEMENT COSTS PER ACRE.

Year	1911	1912	1913	1914	1915	Average
Pruning	\$10.00	\$ 4.92	\$ 4.88	\$ 0.60	\$ 5.20	\$ 5.12
Cultivation	16.00	12.40	10.40	9.95	2.50	10.25
Fertilizing		4.80	.....	.....	.....	.96
Spraying Dormant		6.24	7.08	6.85	5.88	6.51
1st. In Summer	7.10	4.68	5.12	4.65	4.20	5.15
2nd. In Summer	7.45	3.88	4.00	4.95	5.00	5.05
3rd. In Summer	7.30	4.92	5.40	4.80	6.74	5.83
4th. In Summer	7.05	4.44	4.96	5.80	6.50	5.75
Total spraying .	\$28.90	\$24.16	\$26.56	\$27.05	\$28.32	\$26.99
Harvesting fruit..	\$28.60	\$22.00	\$30.00	\$28.25	\$117.60	\$45.29
Total cost.....	\$83.50	\$68.28	\$71.84	\$65.85	\$153.62	\$88.62

Man and team labor are charged at current neighborhood rates, 15 cents per hour for man and 20 cents per hour for team.

The orchard which had never been pruned previously, was carefully pruned in 1911 under the direct supervision of an expert from the Experiment Station. The pruning, together with hauling and burning the brush cost \$10.00 per acre. In subsequent years this dropped to approximately \$5.00 per acre.

Clean cultivation was practiced from the outset. The initial expense of breaking and removing sod from under the trees cost \$16.00 per acre. Cow-peas were used as a cover-crop. Almost immediate results were obtained from this work. Fruit set on the cultivated area much better and was larger than that on adjoining sod blocks. The leaves were a rich, dark green color on the cultivated trees. The line of demarcation between the cultivated and non-cultivated areas was very distinct and could be seen one-half mile away. The average cost of cultivation and cover-crops for the five-year period was \$10.25 per acre.

Only three tons of manure, costing \$4.80, were applied during the five years, this was used as a stimulant to a few backward trees. Little or no effects could be seen from its use.

The most spectacular results were received from spraying. The check crop was each year a worthless lot of fruit while the sprayed fruit sold at profitable prices. A full complement of sprays was applied. The dormant spray of lime-sulphur was made each year after 1911 both for the scale and as a general fungicide. It cost on the average \$6.51 per application. The summer sprays were lime-sulphur-arsenate and bordeaux-arsenate, according to the approved spray schedules. Bordeaux was substituted for lime-sulphur in the later summer sprays because of the prevalence of blotch and bitter rot in this orchard. The four summer sprays averaged \$5.42 per acre per spray. This charge is rather high due to carelessness in application and to the fact that the dilution water had to be hauled one-half mile. The work was started in 1911 with an efficient type of barrel pump. This was too slow, however, and a high pressure, double-cylinder hand pump was purchased in 1912. In 1913 a gasoline engine was added to the outfit. This home-assembled sprayer has given excellent satisfaction. From the spraying cost figures it would seem that the high pressure hand outfit was the most economical. However, the crop of 1912, the year this outfit was used, was the smallest of the five years and therefore less material and less time were expended on the trees. A handy source of water, more care in the purchase of supplies and in the application of material, would reduce the cost of spraying this orchard materially.

In the foregoing table it will be noticed that the harvest items each year are very low. These figures cover the entire harvesting and marketing expenses of the orchard. In years of heavy yield the crop has been sold in bulk f. o. b. cars. The purchaser furnished crates in which the fruit was transported direct from the tree to the cars. This plan of action eliminated all sorting, packing and package charges leaving only picking and hauling to be charged against the crop. In years of lighter yields the crop was

marketed in the orchard or in the small mining towns of the community. The past season was one of bumper apple crops in Indiana and local sales were slack. For this reason a portion of the fruit was barrel packed and sold to an eastern buyer.

The result of past local sales was felt even in this year of abundant yields. The best grades of Grimes, Winesap, Rome Beauty, White Pippin, and Arkansas Black, were sold from 75 cents to \$1.00 per bushel. The bulk of the crop, however, brought only from \$1.50 to \$2.00 per barrel f. o. b. cars.

The five-year average management cost per acre for this orchard was \$88.62. This does not include regular overhead charges of interest, taxes and depreciation on buildings and machinery since our researches were interested only in actual management costs of the various phases of orchard management.

The following table shows the total yield, gross returns, management cost, and net returns per acre for five years from this orchard.

TOTAL YIELD, GROSS RETURNS, MANAGEMENT COSTS, AND NET RETURNS PER ACRE FOR FIVE YEARS; ALSO AVERAGE OF SAME.

Per Acre	1911	1912	1913	1914	1915	Average
Total Yield.....	408 bu.	225 bu.	546 bu.	335 bu.	675 bu.	438 bu.
Gross Returns.....	\$204.00	\$168.75	\$334.80	\$178.50	\$397.25	\$256.66
Management Cost..	83.50	68.28	71.84	65.85	153.62	88.62
Net Returns	\$120.50	\$100.47	\$262.96	\$112.65	\$243.63	\$168.04

METHOD OF SALE.

1911—\$1.00 per hundred pounds at car.

1912—Local sales at orchard. Fifty cents to \$1.00 per bushel.

1913—Fifty cents per bushel at car. Few local sales at 50 cents to \$1.00 per bushel.

1914—Local sales at orchard, 50 cents to \$1.00 per bushel.

1915—One dollar and fifty cents to \$2.00 per barrel at car. Local sales at 75 cents to \$1.00 per bushel.

The five-year average net returns were \$168.04 per acre. From this must be deducted the regular overhead charges of interest, taxes, depreciation and management. To this item, however, should be added the *appreciation* in value of the entire farm. In 1910 the farm could have been purchased for \$50.00 per acre. The owner has now refused a standing offer of \$125.00 per acre.

From the data obtained from this and nine other representative farm orchards of Indiana, we have concluded that the small commercial orchard has a decided place in the general scheme of diversified farming for the middle west.

The farmer who has a certain aptitude for horticulture and who will so arrange his farm crops that they will not compete with his orchard for labor, will find that the fruit growing area of his farm will be the best paying acres that he possesses.

THE WATER SUPPLY AND FRUIT BUD FORMATION.

By W. PADDOCK, *Ohio State University, Columbus, Ohio.*

The speaker is aware that many causes combine to influence fruit bud formation, but he believes that some of these causes are of minor importance in cases where average conditions prevail. In the practice of pruning, for instance, we are often told with great emphasis that much of any pruning of an apple tree is inimical to fruit bearing and perhaps to its life. It is better, according to this plan, to let the tree grow as it will, then when it becomes much too tall and the bearing wood limited to a thin fringe at the ends of the branches, some of the same authorities give us directions for rejuvenating or "dehorning." When this stage has been reached by some process of reasoning, the dangerous effects of pruning and of the severest type do not apply.

Other kinds of trees and plants are most severely pruned, so why not prune the apple. Examples of severe pruning are the peach, in some localities, the plum, hedge plants, various trees used in formal gardening, and grape vines. Do you make the objection that these illustrations do not apply because of the difference in species? Then take the case of the apple tree itself. Surely no advocate of rational pruning in America would care to prune as severely as do the pomologists of Europe. Study the photographs of espalier, cordon and other fantastically trained trees and you will see that very severe pruning must be practiced. But these same trees are fruitful, and moreover, they are long-lived.

So far as there being anything in the notion that severe but rational pruning will shorten the life of a tree, is concerned, I would say that I would not hesitate to recommend apple trees for use as hedge plants if there was any practical reason for doing so. I am sure that they would stand the required pruning and that they would make a substantial hedge.

Have you ever noticed the way in which cattle prune seedling trees that grow in pastures? Before much growth has been made the tender parts are browsed back, thus inducing low branching. This process is repeated season after season and the tree not being able to grow much in height does manage to spread laterally. Finally, a dense bush is produced which eventually becomes so broad that browsing animals do not reach the center. When this time arrives one or more shoots rapidly spring up and form a top which bears fruit. Such trees frequently are both long-lived and fruitful.

Many of the oldest apple trees that one can find are mere skeletons of trees consisting of a few bare poles with a fringe of brush at the ends, yet such mutilated trees may live for indefinite periods and not infrequently they are very productive, considering the fruit bearing area.*

A pear orchard on the Ohio State University grounds was allowed to make the usual growth, that is, several leaders developed

long, slender growth, thus producing trees of familiar type. When the trees were about 15 years old we decided to put them into more compact form. This required severe pruning and in some instances limbs were cut back as much as ten feet. This treatment produced a rank growth of water sprouts and many fruit spurs were transformed into vigorous shoots. But the third year after pruning the trees blossomed profusely and even the water sprouts in many instances produced blossoms.

We have long thought that the apple could be pruned nearly as severely as the peach and in much the same way if there was any reason for so doing. We are not surprised to find that some of our fruit growers are doing this very thing and are meeting with success. This method of pruning is followed by several peach growers in the Port Clinton district. These men are successful peach growers and apples are a side line. Orchardng at long range does not appeal to them, consequently their apple trees are pruned and trained much as their peach trees and with success.

Such facts as the above rather tend toward the conclusion that too much stress should not be placed on methods of pruning as influencing fruit production. Rather should pruning be regarded as a means of controlling the growth of trees. As a matter of fact, success in pruning is largely a question of personal equasion. Where one man is successful many others may fail, and those who belong to the latter class usually do best by patterning rather closely after nature's methods.

Let us discuss the question of water supply and fruit production. An orchard fifteen years old near Columbus, produced a light crop in 1914 and in the spring of 1915 when Ohio orchards generally were loaded with bloom these trees blossomed scantily. The orchard has been well handled in every respect. The soil is heavy, though thoroughly tile drained. What is the cause of failures in the rather numerous examples of this kind?

The speaker has had the fortune to visit orchards during the two years just passed in the states of New Hampshire, Massachusetts, New York, Ohio, Indiana, West Virginia, Virginia and Maryland. The one feature that has impressed him more than all else is the fact that orchards located on stony land, are, as a rule, satisfactory and reliable producers.

Take the famous Hitchings orchard at Syracuse as an example. It only requires a visit to convince one that this orchard is very successful. But there are many others which receive better attention, and yet, are not nearly so productive.

We have here in Ohio several orchards of the same type, that is on stony hill land with partial sod-mulch culture and haphazard pruning. These orchards are noted for being productive and for bearing fine fruit.

To the south of us we soon come to the famous limestone chert orchards. Those of you who are unfamiliar with this kind of land and the productive trees which it produces, have certainly missed something.

Why is it that stony lands apparently are so well adapted to fruit production? It can scarcely be a question of fertility as some of these lands would be classed as poor. Then too, experiments and practical trials have shown that applications of commercial fertilizers often fail to produce greater fruitfulness. It usually is pointed out in these experiments that the organic content of the soil is the crop limiter. But what is the function of organic matter?

The experiments recorded in Technical bulletin No. 9, New Hampshire Experiment Station, tend to throw some light on the subject.

Quoting from page 70:—"There is a current belief in New England that the biennial habit of the Baldwin apple is brought about by rather periodical biennial droughts. It is well supported that withholding water from plants will force them to form flower buds and we have tabulated the rainfall at Durham since the beginning of this experiment in an effort to trace any relation in this orchard between the rainfall and the yield. True it is that this orchard has been profoundly disturbed by its cultural treatments, yet the latter years of the experiment should show a relationship. By consulting the figures, however, it will be seen that no correlation can be established in this experiment. However, we have shown that the low moisture content in Plot 4 has been associated with a high yield and believe if the experiment could be properly controlled this point could be established. It would depend no doubt at just what period in the growing season this drought would occur. The rainfall of one season should be compared with the yield of the next."

The item of special interest in this paragraph is the reference to Plot 4. It is stated that this plot is given clean cultivation, being plowed every spring and cultivated at intervals of two weeks until the first of September. No cover crop is sown and no fertilizer is applied.

By combining some of the tables given in the bulletin we have the following:

Table I. Showing Rainfall at Woodman Orchard for May, June and July and for the Period April 1 to September 1, and Yields of Apples.

	Rainfall Inches.	Total Number Apples.	Rainfall April 1 to Sept. 1. Inches.
1907 May	1.89		
June	2.62		11.81
July	2.82		
1908 May	4.54		
June	.96	23,114 Comparatively light	15.01
July	3.16		
1909 May	1.66		
June	2.46	11,607 Light crop	12.13
July	1.73		
1910 May	1.27		

	June	3.27	401,766	Heavy crop	11.82
	July	1.79			
1911	May	1.10			
	June	1.83	34,155	Comparatively light	13.42
	July	4.96			
1912	May	4.41			
	June	.20	386,324	Heavy crop	12.93
	July	4.14			
1913	May	4.17			
	June	.20	*48,421	Comparatively heavy	12.35
	July	.98	(120,000)		
1914	May	1.22			
	June	1.42	577,135	Very heavy	15.19
	July	3.12			

I do not know that this data is of much value, but it apparently indicates that the amount of moisture present in the ground at about the time when fruit buds begin to differentiate is of prime importance.

The behavior of trees growing in stony land tends to bear out this theory as the water supply is better regulated and good aeration is provided. I believe that the failure of the orchard mentioned above to produce flower buds, was due primarily to too much water in the soil during a critical time.

A similar condition is found in the growing of potatoes in Colorado, so why may it not be true with the apple.

It would appear that a study of the behavior of trees growing in stony soil, as well as of the soil itself, will throw some light on the behavior of trees in general. And it is quite possible that when such a study is made, much which is now obscure and contradictory will be made clear.

TUESDAY, DECEMBER 28, 1:30 P. M.

THE RESULTS OF APPLE PRUNING INVESTIGATIONS.

BY W. H. ALDERMAN,

Experiment Station, Morgantown, West Virginia.

Probably one of the oldest and most universally practiced of orchard operations is pruning. Our earliest records in horticulture mention either directly or indirectly the art of pruning. In fact the horticultural writings of all times have abounded with discussions bearing upon the proper training of the fruit trees. Ancient philosophers and modern theorists alike have expounded facts, fancies and fallacies with a cheerful confidence in their own wisdom and in the accuracy of their teachings. There is a surprising unanimity in the opinions of the various writers which may be explained only

upon the hypothesis that all have drawn their material from a common supply. Such a storehouse of information might very aptly be called hearsay and general observation, for upon investigation we find an appalling dearth of data from carefully conducted experiments embodied in our pruning lore. It is indeed astonishing that a subject which inspired the pens of Pliny and Virgil and which is of acute current interest, should have been so conscientiously avoided by modern investigators.

It is hardly possible in a paper of this length to review the literature of the subject in detail, but a passing reference to the work of two or three men can hardly be avoided. The most noteworthy contribution to the literature came in Bailey's Pruning Book. Bailey brought together, sorted over and correlated a vast amount of scattered information out of which, together with his personal observations, he formulated his twenty justly famous principles of pruning. Since 1898 the spirit of these twenty principles have been manifest throughout the teachings and writings of our American horticulturists.

In the 1907 Report of the Woburn Fruit Station appears an account of a twelve-year experiment largely upon dwarf trees that does not bear out in full some of Bailey's deductions. In this case heavily pruned trees are sixteen per cent lighter at the end of twelve years than those moderately pruned, while unpruned trees were twenty per cent heavier than those moderately pruned. Attention is called to the fact that the difference in weight between the moderately pruned and unpruned was far greater than the difference in weight of wood removed, thus indicating that the pruning even in moderation retarded wood growth rather than stimulated it, a fact contrary to our usual presumption. Girth of the main limbs is reported to have increased in *inverse* ratio to the severity of the pruning. In fruitfulness the unpruned trees exceeded those moderately pruned in the ratio of two to one and exceeded those heavily pruned three to one. It is interesting to note that Goethe of the Eibingen Viticultural Station reports a case where lightly pruned trees increased the trunk diameter two centimeters in a single season, whereas heavily pruned trees increased only nine-tenths of a centimeter. These results serve to throw a shadow of doubt, at least, over some of our long established traditions.

In the Spring of 1911 the West Virginia Station began a test involving various amounts of dormant pruning in one orchard. The following spring, 1912, this experiment was greatly extended to include six orchards in various parts of the state and 515 trees ranging from one to twenty-five years of age. Misfortune under several guises pursued the work from the beginning. Many of the young trees proved to be of mixed varieties; lack of uniformity as to soil conditions not apparent at the beginning, developed in some cases; for two years the crop was injured or destroyed by freezes, and in a few cases the wrong type of data was secured. In spite of unfavorable circumstances some features stand forth clearly and seem to warrant a preliminary report at this time.

It will not be possible in this paper to consider each of the orchards independently or even to discuss the details of organization of each. Instead, we will group the orchards and discuss two phases of the project, the effect upon vigor, growth and fruitfulness of *amount of pruning*, and, *season of pruning*. In most cases the following series of plots were obtained.

1. Heavy dormant pruning.
2. Moderate dormant pruning.
3. Light, or corrective dormant pruning.
4. Heavy dormant and early summer pruning.
5. Moderate dormant and early summer pruning.
6. Early summer pruning.
7. Repeated summer pruning.
8. Midsummer pruning.

The early summer prunings were made at first during the last week of May, but for the last two years were made about June 15. The midsummer pruning was made from the first to the fifteenth of July and the repeated summer pruning was simply a combination of the early and midsummer prunings.

Where varying amounts of dormant pruning alone were considered, we would expect that the heavier the pruning the longer and heavier would be the new growth. This was invariably the case. The question then arose as to whether the average length and diameter of the new growth was a true index of vigor. We are constrained to believe that this was not always the case, at least upon small trees. The heavy pruning greatly reduced the number of buds and consequently reduced the number of shoots which started. It seemed reasonable to believe that though fewer in number the shoots of the heavily pruned trees would actually measure up as great or even greater than those of the lightly pruned block. To test this point, two blocks were selected in one orchard and one was heavily pruned while the other was lightly pruned. Annual measurements were made of the new growth and the prunings. The following table indicates the increase in length of branches and in diameter of trunk each year for four years.

INFLUENCE OF PRUNING UPON TOTAL YEARLY GROWTH.

	Heavy Pruning.		Light Pruning.	
	Length Yearly Growth.	Diameter of Trunk	Length Yearly Growth.	Diameter of Trunk.
At beginning of experiment ..	4.41 ft.	.33 in.	5.58 ft.	.28 in.
1912	16.25 "	.73 "	15.51 "	.68 "
1913	41.53 "	1.15 "	34.33 "	1.16 "
1914	84.08 "	1.57 "	99.39 "	1.86 "
1915	161.74 "	2.17 "	224.89 "	2.91 "

Neither in total length of growth nor in increase of trunk diameter have the heavily pruned trees made as satisfactory a gain as the lightly pruned ones, except at the very first. The only possible deduction from these figures is that continued heavy pruning acts as an inhibitor of growth rather than as a stimulant. It must be borne in mind, however, that no account was taken of the fact that the average diameter of the yearly growth of the heavily pruned block was greater than of the lightly pruned block, so that the real difference in amount or weight of actual tissue produced was not as much as indicated in the table. It is significant to note in this connection that in all the orchards the lightly pruned trees are noticeably larger in size than the heavily pruned ones. With few exceptions the increase of diameter of trunk has been in inverse ratio to the amount of wood cut off.

Thus far we find that heavy pruning forces a rank growth although it retards as a whole the production of wood tissue. There is presented an interesting question of whether heavy pruning and particularly heavy heading back, tends to make more stocky that portion of a branch produced one or more years previous to the pruning. In other words, can a long slender branch be made more stocky by vigorous heading in at the extremity. On the young trees on which measurements were made to test this point, the results were not as clear cut as could be wished, yet they indicate on the whole that heavy heading-in tends to thicken the branch more rapidly than light pruning even as far down as that segment of branch produced four years previously. This is contrary to the results of the Woburn experiment and is not well correlated to our own results regarding the increase in trunk diameter as related to pruning. We frankly admit a high probable error in this part of our data and do not lay undue emphasis upon this phase until substantiated by further work.

In the matter of fruitfulness, interesting correlations were secured. In the one middle-aged orchard in the test, the heavy pruning proved to be a stimulant to fruit production, whereas in the younger orchards, it acted as an inhibitor. Two crops of fruit were secured as shown in the following table.

INFLUENCE OF PRUNING UPON YIELD.

Pruning,	Old Orchard.		Young Orchard.	
	Bushels per tree.	Bushels per tree.	Apples per tree.	Apples per tree.
Heavy dormant....	9.65	14.02	348.6	12.45
Moderate "	8.2	11.94	414.2	19.8
Light "	7.89	9.15	471.7	33.32

In another six-year-old orchard the only fruits produced were upon the light pruned block, and in a five-year-old orchard the light pruned block averaged 85 per cent fruit buds this winter while the moderately pruned block averaged 82 per cent and the heavily pruned block 50 per cent. In young trees heavy pruning has delayed fruit bearing and light pruning encouraged it, but in older

trees that had been bearing for some time and were in only a fair state of vigor at the beginning of the experiment, the vigorous pruning stimulated fruit production. Heavy pruning also produced strong new shoots but did not induce as great a total amount of new growth as light pruning nor did it produce as great an increase in diameter of trunk or size of tree.

We will now pass on to the influence of pruning at different seasons on the vigor and fruitfulness of the trees. The following table indicates the results of summer and dormant pruning on terminal growth in four orchards.

INFLUENCE OF SEASONAL PRUNING ON TERMINAL GROWTH.

	Length of terminal growth in inches.				
	Grimes	Golden.	Lupton.	Boyer.	Sheets.
Heavy dormant.....	14.79	15.87	7.18	28.86	
Moderate dormant.....	12.68	10.74	6.7	13.8	
Corrective	11.36	8.37	5.22	9.67	
Early Summer.....	12.18	10.48	5.96	.....	
Mid-Summer	11.31	8.83	6.59	12.9	
Repeated Summer.....	11.56	8.55	....	.....	
Age of trees—years....	11	9	25	6	

It will be noticed that in every case either heavy or moderate dormant pruning stimulated a greater growth than any of the summer prunings and that the reduction in vigor was less in the case of early summer pruning than with either repeated summer or mid-summer prunings.

The foliage of a tree is a very good index of its vigor. In the season of 1915 a careful study of leaf size, color and number was made in the Lupton and Grimes Golden orchards. In all cases the blocks that had received summer pruning bore a paler or yellower foliage than those pruned in the dormant season. This difference in color was so distinct that there could be no mistaking the summer pruned blocks even at a distance.

The accompanying table indicates the average size of leaves and leaf area per tree for each tree in the several blocks:

LEAF AREA AFFECTED BY PRUNING.

	Lupton.		Grimes Golden.	
	Size of Leaf. Sq. in.	Leaf Area Sq. ft.	Size of Leaf Sq. in.	Leaf Area Sq. ft.
Heavy Dormant	2.77	610	4.99	1143
Moderate Dormant	2.37	432	4.18	911
Corrective Dormant ...	2.10	418	3.52	659
Heavy Dormant plus Early Summer	2.67	524	3.82	794
Moderate Dormant plus Early Summer	2.13	450	3.77	526
Early Summer	2.28	384	3.06	458
Mid-Summer	2.18	284	2.88	480
Repeated Summer	2.07	297	2.42	298

From this table it is clear that summer pruning has caused a great decrease in the size of leaf, number of leaves per tree, and in the total leaf area per tree. If we further consider that these leaves are deficient in chlorophyll as evidence by their light color, we can readily see how greatly summer pruning has decreased the efficiency of the food factory of the plant.

Much of this loss of vigor we have expected, but we have also expected a compensating increase in fruitfulness. In the old orchard the data are conflicting and I will not burden you by enumerating them. In the young orchards we have attempted to correlate summer pruning with early bearing, but the *correlation is negative*. Merely corrective dormant pruning far exceeded all forms of summer pruning in bringing about early bearing, and in some cases the moderate and heavy dormant pruned blocks produced more bountifully than did the summer pruned trees. The writer has serious doubts as to the wisdom of deliberately impairing the vigor and vitality of a tree to throw it into bearing.

THE NEED FOR MORE HORTICULTURAL RESEARCH.

By W. L. HOWARD, *University Farm School, Davis, California.*

In order to introduce my subject I hope I may be pardoned for digressing a moment. A few years ago while spending a part of a vacation in the Sierras, I climbed from the floor of Yosemite Valley to the top of Glacier Point. To those of you who have been there I need not say that this climb required several hours of very severe physical effort. In traveling a mile and a half or less, the vertical ascent amounted to three thousand feet. I was accompanied by my wife and being mindful of her safety as well as my own, I very naturally chose each step of the climb with great care. Often a contemplated step might look safe enough but, upon glancing into the depth below, I would feel the necessity for making a more careful examination of the footing before risking my weight upon it. There were numerous instances when a false step might have sent us both hurtling downward, and it really is not pleasant to contemplate a half-mile drop into space even when in good company. Sometimes what appeared to be firm soil on a ledge turned out to be sand, or what looked like solid rock proved to be loose stones concealed by moss and lichens. Thus the journey was made without mishap but slowly, tediously, because every step had to be proven before the next one could be made.

Now this little experience in mountain climbing is not unlike that of a man who undertakes to write a bulletin, scientific paper, or even to prepare a lecture to deliver in the classroom. Every member of this Society has to do some or all of these things every year. And I ask you how often have you tried to make the points of your discussion safe and unassailable by proving every step you took. Take almost any subject in horticulture, no matter how commonplace, and how far can you proceed with your task if you try to

make all of your statements square with proven facts? Don't you find that every few steps you discover, upon close examination, that what looked to be firm ground turns out to be loose sand and rolling stones? Facts are usually things that have been experimentally proven. Many of the accepted facts of horticulture—statements that are repeated over and over because others have used them, until they have found their way into respectable literature—too often turn out, when subjected to the acid test of careful inquiry, to be mere theories or opinions.

Granting that many of the things we give our students every day as facts are really truths that have been learned by long experience or general observation, I ask if it is not high time that we cultivate the habit of proving our statements by submitting the evidence. But, you object, we would never be able to get anywhere in a discussion—that it is out of the question to try to prove everything we say. And unfortunately this is too true, which brings me to the real subject of my remarks, viz., the great, I might almost say, the crying need, for more horticultural research. I am using the word research here in a very broad sense so that it may include all kinds of experimental work. Correctly speaking, an experiment is an act or operation designed to discover, test or illustrate some truth, particularly by arranging the elements or essential features of some object or process so as to permit of controlled observation, as variety tests of fruits and vegetables, pruning tests of trees, or fertilizer tests with growing plants. Research, on the other hand, is diligent, protracted investigation for the purpose of adding to human knowledge. The ultimate aim of real research is the discovery of natural laws and fundamental truths. Research may, and probably will, include many experimental tests, but the aims of an investigator should reach much farther than the bare results of any tests. The experiments may be regarded as mere steps in an investigation. There appears to be a wide-spread belief that research means something impractical, that it can seldom or never be engaged in with direct profit to a state. Even some station directors—though happily they are in the minority—seem to hold this view.

I do not for a moment under-estimate the value of experimental work. Every horticultural department should have as many experimental projects as can be handled. In this way many theories can be tested and a very great many practical questions answered. Still some dangers may lie concealed along the experimental way for in the very nature of things there are questions and problems that cannot be answered or solved by experimentation alone. Perhaps the chief danger is the predilection for drawing unwarranted conclusions from simple tests. Also students and very young station men may be misled into believing that they are investigating when they are only experimenting, and this may be fatal to their potential future usefulness.

I cannot refrain from prolonging this part of the discussion by saying that investigational work may be the most practical kind of activity that men may engage in. To cite a field of inquiry in which

I may claim more or less acquaintance, I may say that the problem of the rest period of plants—while an investigation seeming on its face to serve no practical purpose, has already been found to shed light on the very live and very practical question of hardiness of fruits in cold climates. And in warm climates, particularly under semi-arid conditions, I am convinced that it will eventually serve as a foundation stone on which to establish irrigation and pruning practices as applied to deciduous fruit trees. Both pomological and irrigation divisions are now carrying on experiments, independently and co-operatively, to determine these things, but I greatly fear that all present efforts are only scratching the surface of the one great question of orchard fruitfulness.

But I have wandered away from my subject as I had meant to discuss it. What I started out to say was that we need more facts pertaining to horticultural questions. Not only should more problems be investigated in an experimental way, but whenever a piece of work is carried out, no matter how small it may be, should we not bend every energy toward establishing each and every step so securely that all will endure the wear and tear of the multitude of other workers who may desire to climb toward other things over the secure stones that we have laid? Let us not despise experiments with commonplace things just because others have been content to pass them by on the strength of current statements (unsupported by experimental proof of any kind) which say that it is best—yea even vitally necessary—to do thus and so, if certain results are to be attained.

I wish I had time to submit a full list of the common things teachers of horticulture have to discuss without being able to offer evidence that would pass muster in a justice court. However, I shall have to be content with a few random shots that occur to me on the spur of the moment: In graftage what is meant by an uncongenial stock, or, lack of affinity between scion and stock? What happens when a bud with its adhering piece of bark is inserted beneath the bark of a stock? Does each part possess a complete cambium layer or each only half a layer? In healing wounds how are two outer bark surfaces, upon meeting, enabled to grow together? What relation does callusing bear to root formation in cuttings? Where can we find some reliable quantitative comparisons of tops and root systems of fruit trees? How does branch pruning affect the root system of trees? Is there a corresponding root for each vigorous new water sprout? What do we really know about the secret of fruitfulness in trees, particularly the fruiting habit? Why do so many apple trees bear on alternate years? Why cannot Ben Davis and Baldwin, for example, be made to bear annually? Why is it an apple tree may bear fruit buds enough for a "full" bloom and only ten per cent really open in spring? What is the true effect of sunlight on fruit bud formation? What are the causes of growth periodicity in trees and the relation of same, if any, to fruit bud formation? What is "hardiness" in trees and buds? What is the nature and cause of coloring in apples? What do we know about

the value of selecting buds in deciduous trees? Is "pedigree" in trees a humbug? Why do certain individual trees appear to have a superior record for fruitfulness? What is meant by vigor in trees? What is the true cause of "June drop" in fruit trees? And so on and so on; all of which makes us painfully aware of the fact that there is a world of things appertaining to common practices which we know little about. But this lack of knowledge should not discourage us as was the case of the fond parent in the story who put his son through a seven years' medical course and then was thoroughly disgusted because the young man could not tell him how to cure a wart.

On the other hand we should be stimulated to greater effort in seeking out facts for ourselves and we should not ignore too many of the little things just because they may seem commonplace. If a young man wants a problem he need not look far to find one. But let us get away from stereotyped statements and try to acquire a new stock of first-hand information.

Somehow or other our horticultural literature has gradually become permeated with dogmatic statements and unsupported opinions which our students are permitted to absorb as gospel truths. Who is to blame for this I cannot say and I fear it would not be profitable to try to place the blame. Conditions are probably responsible for the most part in bringing about this state of affairs. Horticulture is one of the oldest of the agricultural groups recognized by the colleges and stations. Without any experimental facts at their disposal and with little or no facilities for securing experimental information, men were called upon to give instruction in fruit growing and gardening and they met the situation as best they could by drawing upon their own practical experience or the experience of horticultural friends and did their best to explain why certain things had to be done so and so, even though it sometimes became necessary to draw heavily upon their imagination. And in the language of the day they "got away with it" and some of us have continued, more or less, to keep up the practice.

Reform, however, is coming about and coming from a source least expected, viz., from the students that we have to teach. With the rapid raising of standards for entrance in the agricultural colleges, came a class of students with good fundamental training who refused to accept the time-honored statements so general in horticulture without at least plausible explanations. I feel certain that this has been the chief force that has broken the old traditions and is bringing about a brand new horticulture. I am sure a brighter day is dawning and that we shall soon be free from all the hampering fetters of the past.

One reason for my cheerfulness regarding the horticultural situation is the result of an inquiry which I recently addressed to all the experiment stations in the United States. Since there is somewhat of a scarcity of reliable horticultural literature along many lines, I greatly feared that administrative officials might be placing better facilities at the disposal of their departments of chemistry,

botany, etc., but I find that apparently such is not the case. My findings show that approximately half of the stations of the United States have one or more officials in horticulture designated as research men, but that eighteen per cent of these persons do some teaching. However, I did not learn the nature of this teaching. If it is a limited amount of graduate or upper class instruction the men will be all the better investigators, but with too much lower class work their research titles may become a farce. Station directors often reported men as doing no teaching while the men themselves said that under stress of circumstances they were compelled to do considerable teaching. Deans and directors are sometimes great "boosters." From incomplete replies representing thirty or thirty-five institutions, it appears that horticulture is fully as well represented by research men as other departments of the stations.

An effort was made to find out if the output of horticultural bulletins is as great as from other departments, but this part of the inquiry was a failure. Of the nearly 400 "official" horticultural projects now under way in the various stations, about eleven per cent are Adams' Fund investigations and over thirty per cent of the others are regarded as being of research grade.

In conclusion I may add that it appears that the whole range of horticulture from floriculture to pomology now seems to be as well manned as other departments, and if the next few years do not see a greatly increased output of reliable literature, then we are not living up to our opportunities.

ORGANIZATION AND METHODS FOR POMOLOGY EXTENSION WORK.

BY R. W. REES, *Agricultural College, Amherst, Massachusetts.*

Experience has taught the necessity of efficient organization and definite methods of procedure in agricultural teaching and experimental work. Through gradual development there has been a trend toward uniformity in type of organization and methods of work in the various institutions, but even at the present time the systems are far from uniform.

There is still some variance of opinion in regard to the relationships of men in experimental work in pomology and those on the teaching staff of the department in the colleges. In the college work itself we find variations of opinion in regard to teaching subjects related to pomology as botany, entomology and plant pathology. The question arises as to just where the division line shall come in teaching these branches, and we find almost no two institutions which agree as to the exact division.

Extension work is a comparatively new department in all our agricultural colleges and we naturally expect to find it developing along different lines in different parts of the country. At present there seems to be a strong movement toward more uniform systems

of organization, but methods of conducting the work must always vary to meet local conditions in the different states.

It is not my field in this paper to take up the general organization of the extension department and its relation to the experiment station and teaching departments of the college, except in such phases as bear directly on pomology work. I have not made a compilation of the systems used in the institutions of the country, but am merely going to outline the development of pomology extension work and methods that have proven successful at the Massachusetts Agricultural College, with the hope that they may bring out discussion which will be helpful and apply to our individual needs.

In September, 1909, Professor William D. Hurd was called to the Massachusetts Agricultural College to organize the extension department. The principle of organization installed was similar to that existing in several institutions between the experiment station and the departments of the college. The extension man is jointly connected with the extension department and with his particular department in the college. He is responsible to the director of the extension service as executive head and general administrator, and is responsible to the departmental head for technical phases of the work, such as facts taught and methods of bringing these facts before the people of the state.

Where there is joint responsibility and co-operative administration, it is necessary on the part of all to have a very clear understanding as to relationships. This we have been able to bring about. At frequent conferences between the director of the extension service, the extension pomologist, and the head of the pomology department in the college, all projects, policies and needs of the work are freely discussed and a mutual agreement reached. We also find it very helpful to have frequent conferences of all the men on the pomology staff so that those doing extension work may keep in touch with the college and station, and so the men at the institution may be acquainted with the work being conducted throughout the state.

For a time after its organization the extension work in pomology was handled in connection with his regular duties by Professor F. C. Sears, head of the department of pomology. In September, 1910, a man was secured to devote one-half time to teaching work and one-half to extension work. This system had several features to commend it. The method keeps the instructor in touch with outside conditions and gives him a chance to meet many fruit growers and know their problems. It forces the extension man to brush up on many details of work he neglects if devoting full time to outside work. Even with these theoretic features in its favor the system was only partially successful. It is a very difficult matter for a man to do his best in teaching work when away from the college three days a week, and it is difficult to conduct organized extension work when unable to be on the road more than three days at a time.

In May, 1912, the present incumbent was employed to devote his entire time to extension work in pomology. Since that time no men

have been added to the staff to do regular work, but sometimes during rush seasons temporary help has been secured. All men on the pomology staff have co-operated loyally in extension work. During the past two years their assistance with lectures and demonstrations has amounted to more than half time for one man.

In organizing our work we have found the definite project plan to be the most efficient system. We are now conducting six projects. The first is the establishment and care of demonstration orchards. This phase of the work was presented to the Society at its annual meeting in Cleveland in 1912 and will not now be taken up in detail. The demonstration orchards are proving of cumulative importance as the trees become older and the orchards more widely known. At the public pruning and spraying demonstrations, attendance increases annually and there has been a notable improvement in orchard methods in districts surrounding many of these centers. The orchards are each year visited by increasing numbers who inquire of the owner regarding general orchard problems such as culture, fertilizers and spraying. He is becoming known as a local authority on orchard subjects. In other words he is a local extension instructor in pomology. It has been our experience that the demonstration orchard when located with the right man and properly handled is one of the best pieces of pomological extension work.

The pruning and spraying campaign is another project which has shown direct commercial results. This type of work is organized in neighborhoods where apple growing is a leading line of agriculture. As a basis for starting the work we co-operate with ten or twelve men who have commercial orchards and who are interested in orchard improvement. A memorandum of agreement is drawn up between the orchard owners and the extension instructor in pomology whereby the extension department agrees to furnish a man to superintend the pruning for one-half day in each orchard. The owners agree to complete the pruning as started and to carry out recommended methods of spraying. It is our custom in handling this work to have five or six of the orchard owners meet at orchard number 1 and spend the forenoon pruning under supervision. In the afternoon they go to orchard number 2 and so on until one-half day has been spent in each orchard. In this way each man gets 2½ to 3 days' experience and is better qualified to finish pruning his own orchard.

In spraying work we do not spend so much time at each orchard, but give three complete demonstrations in the neighborhood, one for dormant sprays, one for bud sprays, and one for calyx sprays.

The memorandum provides for this supervision covering a period of three years, but in the second and third years a smaller amount of time is spent on the pruning work. The project was started in 1913 and since that time several neighborhoods have been added. As a direct result of this work in three neighborhoods the growers have voluntarily combined to sell their fruit. Owing to

improved quality of the fruit and uniform packs, they have secured 25 to 75 cents per barrel above the ruling market prices.

An apple grading and packing campaign is outlined as a new project, but has not been put into full operation. Under this project work will be conducted in several towns in the fall of 1916. The principle of organization is similar to that in the spraying and pruning work. The work will be started under very favorable circumstances as a new state law for uniform grading and packages becomes effective July 1, 1916.

In all our campaign work we feel that a well explained demonstration is of greater value than the lecture, and past experience leads us to believe that demonstrations supplemented by supervision over actual work is a step in advance of the demonstrations alone.

Extension or movable schools form another line of work. These are of two types, the strictly pomological schools and those covering more general work. The pomological schools are held only in centers where there is a balance of interest in fruit growing. These schools are conducted for five days, each day being divided into four periods of one and one-half hours each. The lectures cover all phases of fruit work from selection of sites and soils, to marketing the crop. It is our custom to make lectures 45 to 50 minutes in length and devote the balance of time to general discussion. We always use all possible kinds of illustrative material, as varieties of apples, types of nursery stock, sprayers, pruning tools, harvesting and packing equipment. Outside demonstrations are given in pruning and spraying and inside demonstrations in grafting, grading and packing. Actual laboratory work is conducted in grafting, budding, packing, and such lines as lend themselves to this form of instruction.

The general extension schools are five-day schools, but the day is divided into six periods of one hour each. Fruit work is given two hours a day. The pomological subjects are taught along the same lines as mentioned above, but of necessity in more condensed form.

For three years the extension department has been carrying on work at the agricultural fairs. The college owns a tent 40 x 72 feet in which exhibits from all departments of the college are shown. In the pomological exhibit we have paid special attention to spraying, pruning and packing apparatus and accessories, exhibits of packed fruit and variety collections. We have a man in charge of the pomological exhibits to give lectures, demonstrations, to explain the exhibit and to discuss orchard problems. The lecture and demonstration work has been only partially successful, as generally the people do not go to fairs to attend lectures. The personal conferences with interested people have proven worth while and justify the time and effort expended.

Our sixth project covers single lectures and demonstrations. There is a great demand for this line of work, but it is our present policy to discourage rather than encourage its development. We feel that greater good and more lasting results are brought about from definitely organized pieces of work which cover a greater

length of time and where the instructor personally meets those with whom he is working. We are particularly trying to keep away from organizations which want speakers to merely fill up the program or for entertainment. We are trying so far as possible to have all lectures and demonstrations on timely and limited subjects which may be fairly well covered, avoiding such general subjects as "Apple Growing," or "The Culture of Small Fruits."

During the past three years we have been able to put part of our lecture work on a course basis so that a series of five or six lectures may be given to the same audience, one lecture being given each week or one in two weeks. This enables the speaker to develop his subject and handle detailed material which is impossible in the single lecture.

I have outlined our type of organization, the projects now in force and methods for conducting the work. Up to the present time most of the work has been carried on by the extension pomologist and men of the college pomological staff. With the rapid development of the county farm bureaus, our policies must of necessity change to meet new conditions. In May, 1913, Massachusetts organized its first county farm bureau which from the first had one man on its staff who devoted his entire time to work in pomology. With the passage of the Smith-Lever bill the farm bureau or county agent work has developed rapidly through the entire country. Since December, 1914, eight counties in Massachusetts have organized and have agents in the field. Two more are now organized and will have men at work early in the year. With eleven out of fourteen counties organized, Massachusetts will have between 85 and 90 per cent of its total area covered by these agricultural agents.

In addition to the county work there are four secondary schools in agriculture and twelve high schools have agricultural departments. As organized, the farm bureaus are closely connected with the extension department of the college and the agricultural instructors in all schools are required to handle a given amount of local extension work. With this large corps of men for conducting extension work throughout the state, the executive duties will be greatly increased for men on the college extension staff.

The work of the extension pomologist will be more largely to help the local men work up their fruit projects and assist in putting these into operation. He should be in close touch with them on all phases of orchard demonstration and supervision work so there will be a uniformity in methods used and matter taught throughout the state. The college man will work more largely through the county agents and local instructors and do less work directly with people of the state.

With the exception of the extension schools the county projects will not vary greatly from those outlined in this paper, but will be handled locally rather than directly from the college.

At a recent conference of all the county agents and agricultural instructors in the state, it was decided to select one problem which should be pushed in a state-wide campaign for 1916. Fortunately

for pomology the choice was to inaugurate a special campaign for the control of the codling moth. As yet details have not been worked out, but we expect to organize and carry the campaign to every apple producing town of the state, to do much broader and more thorough work than would be possible if the college were alone on the proposition.

In summing up the organization and methods for pomological extension work, we believe the principle of close relationship and mutual understanding between the extension service, the experiment station, and the college is necessary for successful development. All extension work should be outlined in form of definite projects so efforts may be concentrated on the most essential problems. With the rapid development of the agricultural county farm bureaus the extension work in each county should be conducted in co-operation with the agricultural agents. In counties which have a pomologist, the work should be largely carried on by him under general supervision of the extension pomologist at the college.

THE ROOT SYSTEMS OF NURSERY APPLE TREES.

BY J. K. SHAW, *Agricultural College, Amherst, Massachusetts.*

An apple tree may be divided into two parts: First, the root system; and second, the trunk, branches, and attached parts. The fact that in most apple trees these two parts are different varieties, one an unnamed seedling forming the root system, and the other a full fledged named variety forming the aerial parts of the tree, needs but to be mentioned before this body. The only exceptions are where a graft has accidentally thrown out roots from the scion or where, for a special purpose, trees have been grown on roots of known varieties. In the first case the root system is part seedling and part a named variety like the top; in the second case the root system may be one variety and the top another, or the entire tree, roots and all, may be a single variety. Rooting from the scion of hardy varieties is sought in our prairie northwest in order to avoid winter killing of the seedling root, should it chance to be tender. In Australia the growing of their desirable varieties on Northern Spy or Winter Majetin in order to avoid injury by the woolly aphid, has become an established practice. This is also being carried on in California at the present time and is the subject of experiment in other parts of the country where the woolly aphid is a serious pest.

The differences between named varieties in both morphological and physiological characters is great and our named varieties are a selected few from the multitude of seedling candidates for favor. Manifestly, the possibilities of variation within the species comprising our cultivated apples is very great.

The interrelations of these many seedlings forming the root systems and the lesser number of named varieties forming the aerial parts of apple trees have been the objects of much speculation and considerable recorded incidental observation, or desultory

experiment. Of the careful, systematic and extended inquiry necessary to solve these complicated problems, there has been very little, consequently our knowledge is fragmentary, incomplete and probably in many ways misleading. Most of the experiments along this line have been with trees each made up of two named varieties, one forming the trunk and possibly a part of the main branches, and the other the remaining aerial parts of the tree, the whole being on roots of an unknown seedling. Whether different or more uniform results would follow if trees having the root system of the same variety as the trunk were used, is unknown.

These considerations led to the inauguration in 1912 at the Massachusetts Experiment Station of what it is hoped will develop into a fairly extensive investigation of this general question of the interrelation of the root and scion in apples. This investigation will necessarily continue many years before conclusions of value may be safely reached. The most striking thing thus far observed is the great difference in the readiness of different varieties to throw out roots from the scion when propagated by means of long-scion short-root grafts. Some varieties will send out roots from the scion in practically every case, while with others a success of two or three per cent is most gratifying. This matter is now being made the subject of a special investigation.

There is much in pomological literature dealing with the influence of the root or stock upon the bearing parts of the tree. Most of this matter deals with what is apparently a manifestation of the direct or indirect effect of stocks of great or little vigor of growth upon the tree. A typical example known to all of the influence of a weak growing stock, is seen where Paradise or other dwarfing stocks are used beneath standard varieties. The opposite influence, that of the top upon the root system, has received little notice, although it is well known that the top exercises great influence over the roots. The main purpose of this paper is to discuss this phase of the interrelation of root and scion, and to record the observations made during the past three years of study of the question.

The domination of the top is so pronounced that the nursery man finds the root system of great value in recognizing varieties. It is so great that it moulds the diverse seedlings into a type of root system common to the variety propagated. Nevertheless, it must be said that within a given variety the form of the root system is less uniform and less characteristic than the form of the top. This is probably due largely to environmental influences, to soil conditions and the influence of the various trophisms to which the roots are subject. The lack of a manifestation of a definite arrangement of the roots as seen in the phyllotaxic arrangement of the buds and branches may also have an influence.

The roots of a nursery apple tree may be classified into the tap root which is commonly of little importance owing to the mutilation resulting from the processes of propagation, the primary branches or main roots, and the fibrous roots. Sometimes the distinction between main roots and fibrous roots is bridged over by intermediate

sizes, but in a general way this classification holds very well. The main roots differ in number, size, length, place of origin, and in the angle which they form with the main axis of the tree. The fibrous roots may be described in similar terms omitting the angle with the main axis.

It is well known that budded trees and root grafted trees are unlike. This, as pointed out by Bailey in the Nursery Book, lies primarily in the type and treatment of the stock used, rather than in the different method of propagation. In either case the tree grows in exactly the same way from a single bud. Budded trees are heavier than root-grafted trees of the same age, principally for two reasons. A larger root is planted in the first place and it is in the ground a year previous to the growth of the top, thus it has a better chance to become established and prepared to give stronger support to the growing bud.

It is asserted that budded trees are deeper rooted than root-grafted trees, but it is very doubtful if this is of any real significance. It rests on the use of a longer root for budded trees, but this cannot cause any great difference, for it is not more than three or four inches at most and in root grafted trees there is always a strong tendency for the main roots to start from the tip of the planted root while in budded trees many of them come from points higher up on the planted root. The appearance of strong roots from the tip when a considerable portion of the root has been cut off may always be seen and is an effect similar to that seen when leaders of the top are headed in.

A constant difference between budded and root-grafted trees is the presence in budded trees of the crown or region of change from root tissue to stem tissue. There is often a tendency for fibrous roots to appear at this point. Also there are generally more fibrous roots in budded trees while the main roots are smaller and more slender though possibly greater in number. The most striking difference in the root system lies in the tendency in root grafted trees for a few strong roots to break out from the cut end of the root. Probably those cases where these are not seen are where the root used was the tip cut. Often they all spring from a common point, giving a one-sided root system. Main branches springing from the side of the planted rootlet are by no means uncommon, but are not the rule as in budded trees. Nevertheless it is possible in most lots of nursery grown budded trees to pick out individuals which have a root system like that of root-grafted trees, and the reverse is true with many of root-grafted trees.

The root systems grown from scions of different varieties seem to react differently towards crown gall and hairy root disease. Certain varieties have not in our experience shown the hairy root form, but always the hard round galls. Jewett is an example of this class. Other sorts, Northern Spy and Oldenburg for example, never show the hard galls, but always short fleshy roots growing in bunches from the main axis. The Red Astrachan seems to develop a more typical hairy root form. The observations on which these tentative

conclusions rest are rather limited and it is hoped to add to them as more own rooted trees come under observation. Some varieties seem to be more or less resistant to the disease and doubtless by propagating on roots of varieties of proven resistance, one might secure trees free from this disease. It may be a question whether crown gall is of sufficient account to warrant the extra cost in propagation on known roots.

There are considerable individual differences in the root systems of trees of a given variety whether budded or root grafted. Whether this is wholly environmental or due in part to the individuality of the seedling root is an interesting question. Not enough known rooted trees have come under observation to determine whether they are less variable than trees grown on miscellaneous seedling roots. This question is in mind for future observation. The few observed seem to vary considerably and apparently are different from trees of the same variety propagated in the usual way. This may be due to the peculiar method of propagation used to secure known rooted trees.

Varieties vary greatly in their vigor of growth in the nursery row. Some varieties maintain a similar vigor or lack of it in the orchard and some seem to change when they arrive at bearing age. Delicious, Esopus and Yellow Transparent make notably light trees in the nursery row, while Rhode Island Greening and Tompkins King make large, strong trees, nearly twice the size of the first named varieties when grown under similar conditions. The question of any correlation of vigor with a certain type of root system has been considered and the only relationship discovered is that of size. A strong, vigorous variety will have a large strong root system, but neither the number of main roots, the quality of fibrous roots, the relative abundance of the two, nor the angle of the main roots or tendency to go down or spread out, seem to bear any relation to the vigor of the variety.

The most striking relation between scion and root which we have observed is the relation in form between the top and the root system. The size or stoutness of the main branches is positively correlated with the size of the main roots and the branch angle with the angle of the main roots and the axis of the tree. In many individual cases this correlation is obscure, but careful observations with large numbers of trees will reveal it. The Rhode Island Greening which produces a broad flat top has a spreading root system. The Oldenburg produces in the nursery two or three stout ascending branches and the root system produces a similar number of stout main branches which go deeply into the ground making it a tree exceedingly hard to pull from the nursery row. In contrast to this the Yellow Transparent makes a top of many short slender branches and a similar root system, which does not penetrate deeply, making this one of the easiest varieties to pull from the nursery row. Many other examples of this relationship in form between the top and root system might be cited. It may be seen more clearly in budded than in root grafted trees, probably because the root is

commonly less mutilated in the process of propagation. I am told by nurserymen that there is a relationship between the habit of the top and the form of root system among ornamental shrubs in general. Those having sprawling irregular tops have a somewhat similarly disposed root system and those with symmetrical, compact tops are more or less like this below ground. I have had no opportunity to personally verify this statement.

In conclusion we may say that the control of the bud or graft over the seedling root system is pronounced. Not only does it govern the size and extent, but also the form and disposition of the root system. This may not be absolute, the seedling root retaining its individuality to some degree, but further observation is needed before a definite opinion on this may be advanced. The reciprocal influence of the root on the scion is also considerable, at least in the determination of vigor of growth and the characters which depend thereon. The full extent and nature of these influences are interesting subjects for future determination.

TREASURER'S REPORT FOR 1915.

Voucher No.	1915.	Dr.	
1	Jan. 2	To C. P. Close, Secretary, attending the meeting in Philadelphia December 29 and 30, 1914	\$14.10
	Jan. 2	“ Stamps	4.00
	Jan. 12	“ Stamps	4.00
2	Jan. 20	“ Rufus H. Darby Printing Co.	
		2000 letter heads	\$7.25
		2000 envelopes (7 forms)	7.25
		5 receipt books	2.50
			17.00
3	Feb. 3	“ Night letter from W. L. Howard, Davis, Cal.	\$1.01
	Feb. 3	“ Night letter to W. L. Howard, Davis, Cal.	1.01
			2.02
4	Feb. 8	“ 1 copper half-tone plate for 1914 report	2.25
	Feb. 9	“ Stamps	2.00
5	Feb. 23	“ Express on manuscript to W. M. Holladay, Annapolis, Md.	.21
	Mar. 5	“ Filing case	.25
	Apl. 20	“ Stamps	2.00
	Apl. 23	“ Stamps for mailing 1914 report	13.59
6	Apl. 17	“ Freight on 1914 reports from Annapolis, Md.	.35
7	May 8	“ Printing 1914 reports, W. M. Holladay	157.90
	May 11	“ Stamps	2.00
	July 13	“ Stamps	2.00
	July 21	“ Stamps	1.00
	July 26	“ Stamps	1.00
8	July 30	“ Rufus H. Darby Printing Co., 300 programs of summer meeting	7.35
9	Aug. 7	“ Torsch & Franz Co., 1915 buttons, Berkeley meeting	4.55
	Oct. 12	“ Stamps	2.00
	Nov. 8	“ Stamps	1.00
	Dec. 2	“ Stamps	3.00
10	Dec. 6	“ Rufus H. Darby Printing Co., 500 envelopes, \$2.50; 300 programs, 1915 meeting, \$7.20	9.70

11 Dec.	21	" Torsch & Franz Badge Co., 150 buttons for Columbus meeting	4.50
			\$257.77
1914		Cr.	
Dec. 29		By balance on hand	\$137.75
1915			
Jan. 14		" Sir W. Moore, Royal Botanic Garden, Glasnevin, Ireland, report 1912	1.00
Jan. 16		" Virginia Polytechnic Institute, report 1913	1.00
Feb. 1		" Oregon Agricultural College, reports 1910, 1911	2.00
Feb. 6		" Ohio Agricultural Experiment Station, report 1913	1.00
Feb. 17		" Georgia Experiment Station, first 9 reports	9.00
Mar. 6		" Purdue University, reports 1905 to 1913, inclusive	8.00
Mar. 6		" State Board of Agriculture, Harrisburg, Pa., report 1913	1.00
Mar. 15		" University of Missouri, reports 1912, 1913	2.00
Apl. 15		" Louisiana State University & Agricultural & Mechanical College, first 9 reports.	9.00
Apl. 23		" Georgia Experiment Station, report 1914	1.00
Apl. 23		" Bukidnow Co., 30 Church St., N. Y., report 1914	1.00
Apl. 23		" University of Minnesota, reports 1910 to 1913, inclusive	4.00
Apl. 28		" Ontario Agricultural College, report 1905	1.00
May 7		" MacDonald College, report 1913	1.00
May 13		" Cornell University, reports 1913, 1911.	2.00
May 15		" Ohio Agricultural Experiment Station, report 1914	1.00
May 19		" University of California, report 1914	1.00
May 19		" State College of Washington, report 1914	1.00
May 19		" Ohio State University, report 1914	1.00
May 20		" University of Vermont, report 1914	1.00
May 20		" University of Nebraska, report 1914	1.00
May 22		" Utah Agricultural College, report 1914	1.00
May 22		" Massachusetts Agricultural College, report 1911.	1.00
May 28		" University of Wisconsin, report 1914	1.00
May 28		" University of Idaho, report 1913	1.00
June 3		" State Department of Agriculture, Harrisburg, Pa., report 1914	1.00
June 7		" University of Maine, report 1914	1.00
June 15		" Louisiana State University and Agricultural & Mechanical College, report 1914	1.00
June 15		" Southern Oregon Experiment Station, report 1914	1.00
June 24		" Kentucky Agricultural Experiment Station, Lexington, Ky., report 1911	1.00
June 30		" University of Nebraska, first 9 reports	9.00
July 9		" Hawaii Experiment Station, reports 1911 to 1914, inc. ..	4.00
July 16		" Kentucky Agricultural Experiment Station, report 1913	1.00
July 16		" P. A. Lehenbauer, Reno, Nev., report 1914	1.00
Aug. 30		" Connecticut Agricultural Experiment Station, first 10 reports	10.00
Aug. 30		" Stationery Office, Dominion Government, Ottawa, Can., first 10 reports	10.00
Aug. 30		" North Carolina Agricultural Experiment Station, report 1914	1.00
Oct. 6		" Agricultural & Mechanical College of Texas, report 1914	1.00
Oct. 6		" Syracuse University Library, first 10 reports	10.00
Oct. 6		" University of California Library, report 1914	1.00
Oct. 6		" University of Minnesota, report 1914	1.00
Oct. 7		" Delaware College Experiment Station, reports 1912, 1913, 1914	3.00
Oct. 13		" Colorado State Agricultural College, report 1914	1.00
Oct. 16		" E. F. Stoddard, College Park, Md., first 9 reports	9.00
Nov. 15		" University of Missouri, report 1914	1.00
Nov. 18		" Pennsylvania State College, report 1914	1.00

Nov. 23	“ Dulan & Co., Ltd., 37 Soho Sq., London, England, first 10 reports	10.00
Nov. 24	“ Washington News Co., Washington, D. C., 2 reports, 1914	2.00
	“ Annual dues paid during the year.....	196.00
		\$468.75
	Balance on hand.....	\$210.98

Respectfully submitted,

C. P. CLOSE, Treasurer.

The Auditing Committee reported that it had examined the accounts of the Treasurer and found them to be correct.

W. H. ALDERMAN,

C. E. DURST,

C. A. McCUE,

Committee.

REPORT OF COMMITTEE ON GRADUATE WORK IN HORTICULTURE.

By M. J. DORSEY, *Chairman, University Farm, St. Paul, Minn.*

The task assigned the committee, as understood by its members, was to investigate the present status of graduate work as now given in horticulture. This is by no means an easy task. The work begins where that of the various committees on under-graduate instruction leaves off. There is a noticeable tendency in most of the institutions not to offer graduate work, or at least they do not see their way clear to make adequate preparation for it until the under-graduate instruction has been taken care of. This is a commendable tendency. The two fields of instruction, of course, overlap, since in horticulture we have the same staff covering the two fields. Even a casual survey of the horticultural departments the country over, shows that there is much variation in the conditions under which graduate work is given. We have had a half century of experience in giving instruction in this field, and horticulture comes along with the “rising tide” of agricultural interest. It would seem important, then, at this period, that a further survey of our different fields of activity be made with the object in view of giving graduate instruction better direction and co-ordination.

We have divided our survey into three main heads: (a) the teaching and research staff; (b) the material equipment, such as laboratory, library, orchard, etc., and (c) the product, or the type of training given.

The report is made up from information obtained from catalogs, personal correspondence, questionnaires, etc. We have depended upon the last primarily for getting the viewpoint of horticultural workers.

TEACHING AND RESEARCH STAFF.

It is difficult to present accurately an estimate of the teaching and research staff of an institution. Conditions under which men work determine, to a large extent, their standing as scientists and the value of their services. In general, however, we may approach a discussion of the staff from the standpoint of (a) training, (b) freedom of time, and (c) specialization.

Part of the individual record is expressed in formal training and degrees, aside from the practical experience. While we should not make the mistake of placing undue emphasis upon the formal training alone, yet experience in other fields shows that it should be given considerable weight, especially with the younger men. Whatever our attitude is in this regard, we judge ones seriousness of purpose in life largely by the preparation made. Formal degrees are, in a sense, a stationary estimate of a man. We shall place chief emphasis upon accomplishments in teaching and research, published or unpublished, subsequent to the granting of degrees.

We have summarized the formal training of the horticultural workers, as expressed by the degrees held, for purposes of comparison.

First, we shall compare the formal degrees of the horticultural workers of 1915 with those of 1905. The following table was compiled from the organization list of the colleges and experiment stations for those years.

	1905					1915				
	Doctors.	Masters.	Bachelors.	No Degrees.	Total.	Doctors.	Masters.	Bachelors.	No Degrees.	Total.
Chief or full Professors..	7	27	13	6	53	13	34	21	1	69
Associate Professors	...	1	...	2	3	3	15	11	1	30
Assistants	...	6	13	5	24	...	23	39	5	67
Instructors	...	6	7	4	17	1	12	36	4	53
Total.....	7	40	33	17	97	17	84	107	11	219

A survey of the table shows (a) that there is a noticeable increase in the group of associates in the ten-year period, (b) that there is a relatively large decrease in the number of horticultural workers holding no degree, and (c) that in 1915 there is relatively a larger number of workers with only the bachelors degree.

Second, the following table is presented, comparing the formal degree of the horticultural staff in sixteen of our larger institutions

scheduling graduate work in horticulture, with those of the staff in the department of chemistry in the same institutions. The portion of the table referring to the chemical workers was compiled from the last obtainable catalog of the institutions represented, while that for horticulture was compiled from the 1915 Organization List of Agricultural Colleges and Experiment Stations.

	Chemistry.					Horticulture.				
	Doctors.	Masters.	Bachelors.	No Degrees.	Total.	Doctors.	Masters.	Bachelors.	No Degrees.	Total.
Chief or full Professors...	34	9	2	...	45	6	19	2	...	27
Associate Professors.....	7	5	1	...	13	3	11	3	1	18
Assistants	25	10	4	...	39	...	11	16	2	29
Instructors	28	12	12	...	52	...	6	11	1	18
Total.....	94	36	19	...	149	9	47	32	4	92

We wish first to point out the larger number of workers in the chemistry group of the rank of instructor and assistant, holding advanced degrees, and second, the larger number of heads of departments with the doctorate degree in order to suggest the probable influence of this advanced training upon the standards of undergraduate as well as graduate instruction and departmental leadership.

From the standpoint of graduate instruction and research it is important that the members of the staff, especially those with the better training and wider experience, have sufficient freedom of time. Intimate connection with the applied field renders this increasingly difficult, particularly with the heads of departments who in many instances must of necessity spend a large proportion of their time with executive work, undergraduates, correspondence, committees, etc. Research and graduate work cannot be placed on their proper footings until the men in charge are surrounded with conditions in which they can make continuous concentrated effort along their special lines.

Undergraduate instruction is, of course, given chief attention. No attempt was made in this report to determine to what extent arrangements are made whereby instructors can have the larger part of their time free from teaching at certain periods of the year for research. Many instructors, of course, are engaged for teaching only, while others are supposed to be investigators. The relative emphasis placed upon teaching and research is not standardized, and from every standpoint needs to be given careful attention. If

the ends sought can be attained by a close relation between graduate teaching and research the stimulus in both directions should not be overlooked. The time devoted to undergraduate teaching and administration is large and the demands of these are immediate, and as a result the graduate work or research must take second place. The attitude of the individual or the department in making the adjustment will be determined largely by the demand or personal desire and qualification.

One of the most effective means of increasing efficiency in the staff as well as gaining a larger freedom of time, is specialization. The administration can no longer ask members of its staff to maintain leadership in more than one field of teaching or investigation. This point is well recognized by some of the larger institutions, but, even yet, in one state, horticulture is being taught by the department of biology, while in contrast to this, in another, pomology is further sub-divided. Those in charge of horticulture in institutions where they are called upon to serve in more than one field, must, owing to human limitations, be placed at a disadvantage. Narrowing of the field covered by any worker need not present any serious difficulties from the administrative standpoint.

The following diagram is presented to set forth graphically the distinction between calling upon a worker to serve his department in a special way or in a general way.

	Pomology	Olericulture	Landscape Gardening	Floriculture
College				
Station				
Graduate School				
Extension				

Crossing the diagram horizontally a worker must be a pomologist, an olericulturist, a landscape gardener or a floriculturist. If carried to the extreme he may be asked to cover all of these four lines of work in the College, Station, Graduate School and Extension. This was the original professor of horticulture. Crossing the field vertically, in any one of the sections, there is a narrowing of the material with which it is necessary to be familiar, and further specialization and division of the work is easily accomplished.

THE MATERIAL EQUIPMENT.

The reports upon equipment show that most of our departments are well provided with a working library, and in some cases a reference library, laboratory space, apparatus, variety plantings, experimental plots, greenhouses, etc. The equipment, however, has been brought together primarily for undergraduate instruction and the experiment stations. There seems to be adequate equipment in most cases available for graduate work, but, to quote one correspondent, "I have a notion that the quality and quantity of material equipment bear no very close relation to the quality of work given." Since the research in horticulture is carried forward almost exclusively from the standpoint of the experiment station, the committee wishes to suggest the desirability of the closest possible relationship between the graduate work and the experiment station research.

Among the significant recent movements toward giving instructors a broader experience and viewpoint may be mentioned the present exchange arrangement between Cornell and Wisconsin. A co-operative arrangement between the Horticultural Department of the West Virginia Station and the Department of Plant Physiology of the University of Chicago, has been made, whereby Dr. Knight in plant physiology spends a part of his year in West Virginia directing and carrying forward some of the research in horticulture. There is evidence from some of the more recent publications in horticulture of the value of special training in some of the horticultural investigations.

In connection with a discussion of our material equipment, however, we wish to emphasize the fact that investigations represent a viewpoint and that equipment and support alone are only a means to the end and not the end. The details are only worked out correctly by trial and experience and they will be fitted into a general scheme only when the viewpoint or general plan of attack is organized and followed. It will rest with the institution concerned to make the proper adjustment between the pressure from the practical man and undergraduate teaching, and the time devoted to research and graduate instruction.

Finally then, from the standpoint of the staff in its relation to graduate work, the committee wishes to emphasize, first, better formal training, aside from the practical experience; second, greater freedom of time, and third, further specialization. This being accomplished, better results will be forthcoming from the material equipment already at hand.

THE PRODUCT OR TYPE OF TRAINING GIVEN.

We now turn to a general discussion of the output in terms of graduate students from our horticultural departments as a whole.

From the reports received, as well as by consulting catalogs, it was found that there are nine institutions offering work in horticulture leading to the doctor's degree, and approximately twenty scheduling work for the master's degree.

The time required was almost uniformly one year's residence or the equivalent for the master's degree. With reference to the type of work required for the master's degree there is some variation, but in general most institutions required the presentation of a thesis based upon original research and designed to test the student's ability and promise as an investigator. Only a few required research in the minor, by far the majority stipulating that the requirements should be met by taking graduate or advanced courses. A few left it optional. Some expressed the opinion that there is not sufficient time within the one year to accomplish much in the way of research, and that the student would be better off in the end by securing a broad survey of his special field and a literature review and write up of some special line of research within it. It seems, however, that since such a large proportion of the workers at the present time go only as far as the master's degree in their advanced training, that in some respects it would be desirable to lay greater emphasis upon research for the master's thesis.

With the doctor's degree there was little variation as to requirements. Those departments of horticulture offering work for the doctor's degree come under the control, in every case, of well organized graduate schools and the standardization of the requirements for advanced degrees is well taken care of by other agencies. The uniform requirements are three year's residence in advanced work, as a minimum. Research in one minor in some related field was generally required. There was a preference that the minor should be taken in botany, chemistry or plant physiology.

It is evident that the requirements for the master's and doctor's degrees are quite generally well recognized, at least the indications are such from the catalog statements. As to just how far the standards are being upheld cannot be determined at this time from our survey. In other fields well organized departments provide for seminars, conferences and schedule advanced courses. This should be the aim in horticulture.

According to the reports sent in, there are registered at the present time, 10 students for the doctor's degree in horticulture and 77 for the master's degree. This does not include reports from Pennsylvania, Virginia, Massachusetts or New Jersey.

Graduate courses in pomology are scheduled in 13 institutions, in olericulture in 9, in landscape gardening in 5, in floriculture in 6, and in plant breeding in 8, while 5 list their graduate work under thesis research. According to the reports received, in the last five years there have been 84 theses submitted in horticulture—19 states only are represented in this total. An analysis of the thesis subjects, practically all of which were for master's degree, shows that 51 could be classified under pomology, 10 under plant breeding, 4 under olericulture, and 1 under landscape gardening. The list was submitted to a worker in another field who classified three of the subjects under entomology, three under plant physiology, three under bacteriology, two under soils and two under irrigation, with the remainder unclassified.

The thesis subjects classified under pomology, plant breeding and olericulture, are included in this report for comparison and study as the result of a number of requests from the members of the Society. The name of the graduate student and of the institution is withheld. The questionnaire asked only for thesis subjects submitted within the last five years. The subjects are more representative for pomology than olericulture, since more replies were received from pomology, even though a statement was requested for horticulture.

POMOLOGY.

The factors which influence the occurrence of seeds in citrus fruits.

A monograph on the almond.

The apple in Georgia.

A sterility study of apples.

Pomological classification of the peach.

The problem of the correlation of texture and composition of apple wood with hardness.

A survey of the commercial apple growing in Michigan.

Grafting.

Economics of marketing.

Some phases of the cold storage problem.

Succession of small fruits for the home garden.

Study of sterility in the strawberry.

The relation between structure and hardness in the plum.

An investigation of reproductive and vegetative activity in fruit trees.

The killing of plant tissue by low temperatures.

Trunk injuries and diseases of apple trees.

A study in marketing the Ozark strawberry crop.

Relative susceptibility of resistance of the various tissue systems of peach flowers to injury from cold.

Relation of season of transplanting to growth and development of fruit trees.

The influence of anaesthetics upon root development of cuttings.

A study of methods in marketing the Missouri apple crop.

The pear industry in New York.

Wholesale prices of apples and receipts of apples.

Root growth of young apple trees after July first.

Some newer varieties of apple adaptable to New York.

Keeping quality of apple in cold storage as affected by handling in the orchard.

Market season of fruits in New York City.

Cost of growing an apple orchard.

Methods of marketing fruit.

A monographic study of *Juglans Regia*.

The peach industry of New York State.

The pecan in the United States.

Raspberry, currant and strawberry.

Pollination studies with the strawberry.
The pear as affected by moisture supply.
A study of plum pollination.
A comparative morphological study of apple varieties. (Internal structure.)
The influence of the angle of shoots upon the development of their buds, spurs and branches.
A study of the fibro-vascular system of the apple.
A comparative study of the cooking qualities of certain apple varieties.
Some factors affecting the cooking qualities of pears.
Modern marketing and storage methods.
Study of the relation of variation in apples to their keeping quality.
Promising varieties of apples that have originated in Washington.
Methods of propagating fruit trees by hardwood cuttings.
Cover crops: Their relation to soil, moisture and temperature.
The vitality of pollen as influenced by time and conditions of storage.
A study of the species of *Malus*.
Development of fruit buds in varieties of apples.
Growth and fruiting characters of strawberries as influenced by different soils.
Self-sterility in varieties of apple.

PLANT BREEDING.

Value of F_1 hybrids in tomatoes.
The inheritance of doubleness, color, mottling, height of plant, and earliness in some annual flowering plants.
Inheritance of different degrees of albinism.
Inheritance in gourds.
Color inheritance in the petunia.
An inquiry into the nature of a somatic segregation of characters in the Le Conte pear.
Genetic crosses.
The effect of crossing on the yield in corn.
Cross breeding lupines.
Cross breeding experiments with the radish.

OLERICULTURE.

Factors in forcing of rhubarb with special reference to use of anaesthetics, temperature, light and other factors.
Factors influencing the yield and quality of tomatoes for canning purposes.
Growing tomatoes under glass.
Potato studies.

There is a noticeable tendency for the thesis subjects to follow the special lines of research in the experiment station. This is particularly noticeable at Missouri, Nebraska and Virginia. This is very desirable and in a way emphasizes the helpful influence of the experiment station research.

At the sixth annual meeting of the Society, Dr. E. W. Allen reported that of the 45 horticultural projects submitted under the Adams fund nearly one-half were breeding investigations. It would seem from the reports that, with the exception of a few institutions, these investigations have not been carried to the point where they are having a large influence upon graduate thesis investigations.

A general criticism of the thesis subjects would be that they are too broad in scope. More specific problems can be carried further, and more can be accomplished within the time limits of either advanced degree. Judging from the thesis subjects it is apparently more difficult to study intensively than extensively. The results of thesis investigations should be published, as other departmental research, when valuable results are obtained.

Nearly all of the institutions offering graduate work have assistantships or fellowships, varying in amounts from \$100 to \$1000 a year, available in the department of horticulture. These assistantships seem to vary considerably in character and also in the residence allowance permitted. Some were teaching assistantships, some research, and some were full time fellowships. As far as could be ascertained, no sharp distinction was made between the types of assistants as to time allowance. Extracts from the letters of two correspondents are included which set forth quite clearly the principle involved in residence credit for graduate assistants.

"In regard to the research assistantships, I think that students ought to be allowed full residence if their assistantships permit them to spend all of their time on research work. This has been our custom here. On the other hand, if the assistantship is such that the holder is doing a considerable amount of routine work for the professor in charge, I should think the amount of credit would be determined by the professor. In other words, the amount of credit ought to depend on whether the assistantships are established entirely to help the student or primarily to help the work of the professor."

"Our graduate assistants are employed on the half-time basis. The term of employment is for the calendar rather than the academic year, even though the young men are allowed an equivalent of one month's vacation in each calendar year. At the end of two years they are allowed to present themselves for the master's degree. It will also be possible for those of our graduate students who may care to remain here for a period of four years to secure the doctor's degree in that length of time."

A considerable increase in the number of assistantships available to graduate students is in some respects desirable, since there is an opportunity to pick men of promise and good training for them. From this standpoint some control can be exercised over the type of student entering upon a course of advanced training.

According to the answers to the query as to whether any professional or honorary degrees are offered, only two institutions reported that degrees of any kind were given other than the regularly earned master's or doctor's degrees.

The diversity of view with reference to graduate study in horticulture is well shown by statements taken from correspondence received in the cause of this inquiry. Some are quoted below. All sections of the country are represented.

"I have attempted brief answers to your questions, but must express my feeling that, so far as horticulture is concerned, the matter of graduate work is yet in infancy and methods of procedure are not well defined. Letters from men in other institutions asking about available problems for graduate work in horticulture indicate that difficulties in choosing problems are generally appreciated.

"There is no dearth of problems. The difficulty arises in so dividing and limiting a problem that the student may have some hope of reaching results within the time limit. Usually work begins in September just at the close of outside plant activities and must be completed soon after growth begins in spring. This time limitation must of necessity eliminate many problems. For most students only problems that may be carried on under glass through the winter are available and most of such problems are within the province of physiological botany just as much as they are within the province of horticulture."

"We have nothing to do with any undergraduate teaching, but for several years past we have taken a strictly limited number of carefully selected graduate students and have taken them right in to the department and put them at work on problems. We do not attempt to give them any course work but simply to direct the research part of their graduate study. We believe here that this works in a very satisfactory way, both from the station standpoint and from the university standpoint. It needs, however, to be very carefully safeguarded at a number of different points or otherwise it will make difficulties. I think that under no circumstances should a station of this sort be open indiscriminately to graduate students. One must be able to use selection."

"I am most heartily in favor of separating research work from all undergraduate teaching. Experience * * * * has given me an opportunity to try both plans and so far as I

am concerned, the advantages are greatly in favor of separate institutions for the two distinct lines of work. I am strongly of the opinion that a limited number of graduate students are helpful to the man doing research work and ought to be of great value to the student."

"With reference to master's students I am very strongly of the opinion that it is idle to expect them to do original research work. We do not have any master's candidate doing such and do not expect to have. We require him to write a thesis and to get up the fundamental courses such as soils, botany, and chemistry that he should have for any sort of college work in pomology. We do not expect to take many candidates for the doctor's degree."

"I think graduate work in horticulture should be done largely in the departments of plant physiology and plant breeding particularly, with probably some work in pathology and entomology. Outside of thesis work I can see very little opportunity for graduate work in horticulture proper. After having had one year's graduate work, majoring in horticulture and minoring in entomology, if I were to plan again to take up graduate work, as I fully intend to do, I would major in plant physiology and minor in plant breeding."

"Of course I assume that all candidates for the doctorate anywhere would expect to fulfill requirements generally regarded as essential to this degree and to present a dissertation which would pass muster as a good doctor's thesis. On the other hand, just what should be the requirements and content of the work required for the master's degree? If an attempt is made to hold a student to working out some original problem in an investigation, the one year usually required for a master's degree is a very short period in which to work out most original problems. It would be of great interest to me personally to know how far the different institutions find it feasible to require the working out of an original laboratory or similar investigation problem, or how far they find it desirable to go over the literature and work up what is known to them concerning a question, irrespective of whether it entails the working out for themselves of any original laboratory problem. Personally, I have sometimes felt that a candidate for the master's degree attempting the working out of an experiment means that in the year he will accomplish often very little with his experiment and yet in his strenuous attempt to get enough out of it to make a master's thesis, he will do very little in the way of exhausting the literature of that subject or to become well grounded in what is already known about it."

"As to graduate work in horticulture as such, I would not recognize that the assignment of a strictly horticultural subject as a doctorate thesis would be entirely correct, although, of course, every institution in the country will unquestionable continue to do this. The subject work for thesis must in my judgment be purely scientific statements. While horticulture is an art in very large measure, the study of any one factor of scientific nature that will be selected for graduate work will fall within some one of the primary sciences. Of course, from the conditions existing, we shall naturally have many of these subjects assigned in the department of horticulture, even though they refer more directly to a pure science. After all I presume we must consider that the nature of graduate work will depend upon the character and caliber of the instructor in charge of it, regardless of where this work is conducted."

"Owing to the limited size of our teaching staff in the College of Agriculture, we find our hands so full of undergraduate teaching that we have been unable to offer graduate courses. It is true that some graduate work has been done, but this year we decided not to grant any graduate work whatever until we were in a position to handle the work more efficiently."

"In this connection it should be stated that there is no horticulture work, as such, in this college. Horticulture has been divided into its several branches, and in some instances we have even gone so far as to sub-divide these."

"I may add we do not particularly advise such graduate work. Our regular bachelor of science students have such a good chance at practical work in handling estates, if they do not already have a home place, that they usually look in that direction after a year or so as assistants."

"Since I have been connected with the institution, I have not encouraged our own graduates very largely to take graduate work here. I tried to impress upon our students the necessity of taking graduate work in some large eastern institution where facilities are better for doing graduate work."

"I have never felt like trying to develop graduate work at this institution until I became a good deal better satisfied with the quality of the undergraduate work than I have been in the past. The institution, as are most others, is limited in its funds and can not hope to do everything well. I have advised a number of our men who are interested in graduate work to take it somewhere else. Ordinarily I think this

is sound advice no matter how well qualified an institution is for graduate work. I doubt if it is often desirable for a man to continue at his Alma Mater to work for an advanced degree."

"The Agricultural College here has not encouraged graduate work to any great degree. The University committee on graduate study does not think that the different departments in the College of Agriculture are sufficiently equipped to give major courses even for master's degree."

From what has been presented it will be evident:

- 1: That we confront a condition or a stage in the evolution of horticultural instruction quite similar to that in other applied fields, and that development has gone further or in different directions in some institutions than in others.
- 2: That graduate instruction in horticulture is not well organized, nor is the type of work which should be given well recognized.
- 3: That the difference in purpose of graduate and undergraduate instruction should be better recognized in order that a clearer distinction can be made between them. In this connection it will be evident that (a) the chief object of the undergraduate instruction is to train the student to think and to obtain a working knowledge of a large body of facts, methods and technique, within a particular subject group. Known facts systematically arranged are dealt with. And (b) that the chief object of graduate instruction is to train the student for independent constructive thinking and research. The body of known facts dealt with is broadened and research and thinking may lead to new fields or methods, or, known methods and technique may be taken and applied in a new field.
- 4: That the formal training of workers in the horticultural field is not equal to that of the staff in the sciences, as chemistry. Among the factors which bear upon this condition may be mentioned (a) the demand for men in the practical work, (b) the rapid development of the work in point of attendance and differentiation of the field, (c) ideals of the heads of departments and the administration as to the type of training demanded in men selected.
- 5: That from the standpoint of the future better trained men on the teaching and research staff, either of the lower or higher rank, will have a direct influence upon (a) the undergraduate instruction, (b) upon the graduate instruction and (c) upon the station research. The interdependence of these in our agricultural colleges will be evident.

To conclude, the committee has attempted only to investigate and report upon the present status of graduate work in horticulture. The investigation has not been of such a nature, nor has it been carried far enough, to make definite recommendations. As a result of our survey, however, we wish to suggest two lines of inquiry which seem to us to be the most needed and the most vital at present to be investigated thoroughly and reported upon, by the committee on graduate work, one year hence.

First: What is the best type of thesis research to be assigned to graduate students majoring in horticulture?

- a. For the master's degree, or not, as the case may be.
- b. For the doctor's degree.

It is understood that aside from the type of thesis special attention shall be given to (a) the scope of the work or ground covered and (b) suggestive outlines of selected topics.

Second: What is the best probable provision that can be made under our present conditions to raise the standards of graduate work in horticulture?

It is understood that under this heading special attention shall be given to (a) the desirability or the advisability of requiring the thesis research to be carried forward in the department of horticulture, or in one of the fundamental sciences, such as plant physiology, ecology, chemistry, soils, genetics, etc., (b) the influence upon graduate work of separating the college and station work, (c) the advisability of a closer relation between the station projects (especially the Adams fund projects) and graduate thesis investigations, (d) the best adjustments or arrangements within the staff, so that more time of qualified instructors can be given to graduate work.

REPORT OF THE COMMITTEE ON POMOLOGY.

By W. PADDOCK, *Chairman*,

Ohio State University, Columbus, Ohio.

A study of the reports of our Society reveals the fact that instruction in the various branches of horticulture is approaching something like a system in the various colleges.

As has been pointed out, conditions vary in the different institutions, consequently a certain course may be given at one place and omitted at another. But in the courses themselves, the catalogues show a growing similarity. We feel that the outlines published in the reports have been of the greatest value in this respect. They must be of especial value to the younger men as aids in shaping their work and in giving the idea of system.

The general work of the Society has promoted the exchange of ideas, a feature which must result in progress. Not so many years ago outlines of courses of study, teaching methods, and laboratory outlines were jealously guarded. Today we are helping the cause by being free with our outlines, plans and schemes. Any one should now feel free to call upon the chairmen of the various committees, at least, for information along these lines.

We note with satisfaction that the subject of vegetable gardening is receiving more attention in the colleges. Just why this subject should have been relegated to the background is difficult to understand. Certainly the products of the garden have always been, and always will be, of more importance than are those of the orchard.

The committees on vegetable gardening, on floriculture and on pomology, do not wish to report farther at this time, but refer the members to the fairly complete write-ups that appear in the last reports of the Society.

Now that we are beginning to get some system into our college work, we need to turn our attention to graduate work. This is a field that is yet practically untouched. Our committee on graduate courses can be of great help in getting this work started. Outlines of courses and suggested topics for theses will do more good in this connection than many pages of theories. Of course, most of us can work these things out after a fashion, but a free exchange of working ideas will be of the greatest help.

In conclusion we would suggest that a committee on instruction exhibits be appointed by the Society. The duty of the committee to be to arrange for exhibits in connection with our Society meetings. Such exhibits to consist of outlines, laboratory syllabi, teaching helps of various kinds, together with results as shown by student work.

INHERITANCE OF SEX IN THE GRAPE

BY W. D. VALLEAU, *University Farm, St. Paul, Minn.*

(This address will be published in some technical journal, but the author was unable to tell the Secretary which one when the report went to press.)

WEDNESDAY, DECEMBER 29, 9:30 A. M.

INHERITANCE IN TOMATOES.

BY G. W. HOOD, *Experiment Station, Lincoln, Nebraska.*

Problems of heredity have been considered fundamentally important for some time, and during the last few years this work has made rapid strides. Many hybridization experiments have been instigated, both in plants and animals, with the view of studying heredity characters, but prior to Mendel's investigations very little was accomplished.

The object of these experiments was to study the unit characters found in dwarf and standard varieties of tomatoes and to attempt to produce something superior to that which already existed in the way of a commercial market variety. It is well known that tomatoes are undergoing sudden and rapid changes, and distinct types are

appearing which are probably the result of discontinuous variation.

These experiments were begun in the spring of 1912 at the Michigan Agricultural Experiment Station. The parent plants and the F_1 generation were grown there, but, owing to my change of official position, the F_2 and succeeding generations were grown at the University of Nebraska.

METHODS AND APPARATUS.

The seeds of the parent plants were sown in the greenhouse March 15, 1912. The soil was a compost made of one part cow manure, one part sod and one part sand. This was prepared the previous fall. The soil was sifted and placed in the flats to within three-fourths of an inch of the top. The seeds were planted one-half inch deep in rows which were two inches apart. Three weeks after the plants appeared they were transplanted to similar flats two by two inches apart, and allowed to become well established, then they were transferred to hot beds. Here they were permitted to grow until May 19, when they were set in the field.

The plants were set four by four feet in the field and were staked and trained to one stem. The usual methods of cultivation were given during the growing season.

The work of hybridizing was begun June 25, and continued over a period of three weeks. Two hundred and fifty-two attempts were made of which thirty-six were successful. Strong healthy flowers were selected, and all but two or three in the cluster were removed. The buds were covered with paper sacks. Out of thirty-six crosses several were duplicates. In every case except one the Dwarf Stone was used as one parent, with the view of studying the height, growth, and the dominant and recessive characters of the plants. One standard cross on a standard was successful.

The following list includes the successful crosses:

1. Prosperity x Dwarf Stone.
2. Dwarf Stone x Prosperity
3. Earliana x Dwarf Stone.
4. Dwarf Stone x Earliana.
5. Dwarf Stone x June Pink.
6. June Pink x Dwarf Stone.
7. Stone x Dwarf Stone.
8. Dwarf Stone x Stone.
9. Dwarf Stone x Bonny Best.
10. Comet x Dwarf Stone.
11. Ponderosa x June Pink.

F_1 GENERATION.

Seeds of the F_1 generation were planted March 20, 1913, in the greenhouse, and handled in the usual way. On April 3, the seedlings were transplanted two inches apart in flats. The plants were then divided and a part transferred to hot beds and the remainder

to the greenhouse. On May 1 the second lot of plants was set in the permanent beds in the greenhouse where they were grown to maturity. Five plants of each cross, as well as a similar number of parent plants, filled a small greenhouse.

The first lot of plants, which had previously been transferred to the hot beds was kept growing, and finally set in the field May 31.

The usual commercial greenhouse methods were practiced, growing the plants at a night temperature of 58°F. and a day temperature from 70° to 75°F.

The field methods were the same as used under ordinary field conditions. The plants were handled in two ways, namely, part of them were staked and pruned to one stem, and the remainder allowed to grow in the natural way with no pruning or training.

NOTES ON F₁ GENERATION.

In observing and recording data in the F₁ generations, many things of interest were noted, and in some cases no explanation is offered. In the greenhouse five plants of each cross were used and the average results for each cross are found in Table I.

TABLE I.

TOTAL AVERAGES OF CROSSES.

Name of Plant	Av. No. Clus's	Av. No. Fruits	Tl. Av. Weight	Ave. Weight	Av. No. Diseased
D. Stone x Prosperity..	5.00	14.00	44.6	3.00	1.6
Prosperity x D. Stone..	4.50	14.00	50.00	3.60	1.5
D. Stone x June Pink..	5.00	17.00	43.00	2.53	2.6
D. Stone x Bonny Best.	4.25	15.75	50.25	3.25	1.5
Earliana x D. Stone...	5.00	10.50	44.00	4.30	4.5
D. Stone x Earliana....	5.00	15.00	48.5	3.25	5.0
Comet x D. Stone.....	5.50	17.50	49.5	3.00	2.0
Stone x D. Stone.....	5.75	14.50	44.00	3.00	2.5
June Pink x D. Stone..	5.00	11.00	23.00	2.10	2.0
Ponderosa x June Pink	6.50	16.00	69.50	4.55	0.5

It was found that the average number of flower clusters taken on the same date and at the assumed maturity of the plant varied from 4 $\frac{1}{4}$ to 5 $\frac{3}{4}$ to the plant where the Dwarf Stone was used as one parent, and 6 $\frac{1}{2}$ when two standard plants were crossed as indicated by the one cross. This might not prove true had a number been taken.

Likewise when the Dwarf Stone was used as the female parent of the cross, the total average number of flower clusters was greater than when the standard plant was used as the female. This increase in number of flower clusters occurred in two cases, while in two other cases the total average was equal, indicating a point in favor of the dwarf plants being used as the female.

If we attempt a correlation between the average number of flowers and the average number of fruits that set, it seemed to be in favor of the dwarf plant when used as the female. This phenomenon was observed in each of the crosses and varied as an average of all of the plants from one to seven fruits. While there seemed to be a difference in favor for the dwarf plant when used as a female, if we consider the number of flower clusters, this difference could not be carried to the total weight of fruit. In individual cases this seems to be true, but there were equally as many that were not true.

Summing up this phase, then, we are led to believe that even if the number of fruits that set do favor the dwarf plant the total weight will not be materially affected because the plant will produce larger fruits when fewer in number. For some markets it might be an advantage to have a greater number of smaller fruits rather than a few larger ones.

When we consider the average weight per fruit and the total weight per plant, there seemed to be no correlation as seen previously (Table I). The average weight per fruit fluctuated around 3 ounces, and varied from 2.10 to 4.55 ounces with individual specimens weighing from 1 to 14 ounces.

SUSCEPTIBILITY TO DISEASE.

There was a great difference noted regarding the susceptibility to the attack of certain fungous diseases, particularly the rots. The average number of diseased fruits attacked by the blossom end rot, varied from 1.5 to 5 fruits, making a per cent varying from about 10 to 33. The Dwarf Stone x Earliana cross and reciprocal, were the most susceptible with practically no difference between the two, the one averaging 4.5 fruits and the other 5 fruits. The Dwarf Stone x Prosperity and reciprocal cross showed the least susceptibility, giving 1.6 and 1.5, respectively.

Perhaps a strain of tomatoes could be developed which would be practically immune from certain diseases, because this work would indicate that there is a great variation in the susceptibility of many varieties. I think some of our important work must be along the line of producing disease resistance strains, since diseases are causing great losses annually.

VARIATION.

In the progress of either plant or animal life, we are compelled to deal with individual variation which might be said to be the result of three factors, namely, environment, training, and heredity.

My work with tomatoes gave considerable individual variation, which, of course, is to be expected, and this is partly due to environment and training, but these two factors must necessarily be the less important, because all conditions were made constant in order to learn of the variation due to heredity.

Some considerable somatic variation was found in the tomatoes. To a large degree this was due to heritable influences, since all the environmental factors were maintained as near constant as possible. There was considerable variation in the size of the plants, some were tall while others were short. The plants in the F_2 generation all fluctuated around a mean height and this we call a fluctuating variation. By examining the tables it will be seen that the mean height was 53 inches though the growth varied from 51 to 60 inches. These results occurred when the standard parent was used as the male. It will be seen also that the mean around which the fluctuating occurred was greater than the dwarf parent, and known as plus. Taking a standard mean 51 inches, we would have a deviation of 2 inches plus.

TABLE II.

COMPARISON OF RECIPROCALLS, DWARF AND STANDARD VARIETIES.

Crosses	Average height inches.	Average flower clusters.	Average total flowers.	Total average flowers per cluster.	Average No. fruit set.
Prosperity x D. Stone F_2	54.0	6.0	36.0	6.0	15.0
D. Stone x Prosperity F_2	61.0	7.0	38.0	5.5	14.0
Prosperity	52.0	10.0	75.0	7.5	14.0
Dwarf Stone	51.0	5.0	21.0	4.0	11.0
Earliana x D. Stone F_2	53.0	5.6	34.0	5.0	10.0
D. Stone x Earliana F_2	62.0	5.6	33.5	6.0	13.5
Earliana	43.0	2.0	9.5	5.0	3.5
D. Stone x June Pink F_2	59.0	7.5	45.0	6.0	11.0
June Pink x D. Stone F_2	53.0	6.6	32.0	5.0	11.0
June Pink	46.5	5.5	36.0	6.5	5.5
Stone x D. Stone F_2	61.2	4.7	40.4	5.5	12.1
Stone	54.0	4.0	20.0	5.0	11.0
D. Stone x Bonny Best F_2 ...	54.0	7.33	66.6	6.0	11.5
Bonny Best	52.0	6.5	35.0	5.0	7.5
Comet x D. Stone F_2	51.0	5.0	28.0	5.0	7.0
Comet	50.0	7.5	45.5	6.0	13.0
Ponderosa x June Pink F_2 ...	67.0	6.5	42.5	6.5	13.25
Ponderosa'	86.0	10.0	96.0	9.0	25.0
June Pink	46.5	5.5	36.0	6.5	5.5

If we look farther and also examine Table II, it will be seen that the standard height of the reciprocal cross, or where the dwarf plant was used as the male, the average total height was increased about 9 inches, but there was also a fluctuating variation in height around a given mean, and this mean was increased considerably when the standard plant was used as the male parent, instead of the dwarf plant.

RECIPROCAL CROSSES.

It has been pointed out by previous workers that in some species and varieties of plants, the reciprocal crosses were impossible while the plants would cross readily the opposite way. I found this was apparently the case with the tomato because in each cross reciprocals were made, but only three were successful.

A plausible explanation might be made here relative to the increased yield, number of fruits, etc., that when the dwarf parent was used as the male in so far that the reciprocal, even though it did take, was weaker and the constitutional vigor impaired, which reduced the yield. It is reported that in some cases the reciprocal does take, but the resulting progeny is weak and inferior. Further work is necessary, however, before this point can be determined with certainty.

LENGTH OF TIME REQUIRED TO RIPEN FRUIT.

In these experiments the time required for the crossed plant to ripen its fruit was longer than for either parent. The actual number of days later than the parents varied in every cross, and ranged from 19 to 30.

If we consider a concrete example we find the following to be true. Counting the number of days from the time the fruit sets until it ripens, we find in the crosses of the Dwarf Stone and Earliana it required from 35 to 38 days, while the Earliana and Dwarf Stone fruits ripened in about 30 days.

NOTES OF F_2 GENERATION.

According to Mendel each cross has differential characters, and certain of these characters are dominant while certain others are recessive, and certain factors will be apparently inherited to the exclusion of certain others. The expression of these recessive units will all appear in the F_2 generation in the ratio of 3 dominants to 1 recessive or a 3 to 1 ratio.

In the work with tomatoes where the dwarf and standard varieties were used, there were dominant and recessive characters, and the particular character which was determined was tallness.

The F_1 generation produced plants that were all standards; that is, plants that grew 5 to 6 feet in height and resembled the standard parent. Another character which was very pronounced was that of leaf differences. The general leaf character of the

standards seemed to be dominant over the leaf characters of the dwarfs, the leaves of the dwarf being much larger and coarser than the leaves of the standards.

The F_2 generation, according to Mendel, should give all the possible combinations of characters, and we should expect to find them produced in numerical ratio of 3 to 1. This was found to be true with respect to the character of height.

TABLE III.

RATIO OF DWARF PLANTS IN F_2 GENERATION.

Crosses.	No. Dwarf Plants.	No. Standard Plants.	Total No. Plants.	Per cent Dwarfs.
D. Stone x Prosperity..	120	356	476	25.2
Prosperity x D. Stone..	98	263	361	27.4
D. Stone x June Pink..	89	392	481	18.5
June Pink x D. Stone..	87	370	457	19.2
Earliana x D. Stone....	91	234	325	28.0
D. Stone x Earliana....	74	274	351	21.0
Comet x D. Stone.....	137	508	645	21.2
Stone x D. Stone.....	59	154	213	28.1
D. Stone x Bonny Best..	197	772	969	20.3
Sum Total	952	3326	4278	
Total average per cent.				22.3

In the F_2 generation, which is tabulated in Table III, it is seen that a total number of 4278 plants were grown, of which 952 were dwarf, and 3326 were standard plants. This gave a percentage of 22.3. According to Mendel's ratio of 3 to 1, or the theoretical percentage of 25, there is a divergence of 2.7 per cent between the expected, or theoretical count, and the observed results. These results are obtained when all plants are considered regardless of the different standard parents. However, some individual crosses gave slightly different percentages. Take two concrete examples as seen in Table III, the Dwarf Stone x Prosperity and reciprocal, the actual observed percentages were 25.2 and 27.4, respectively, while with the Dwarf Stone x June Pink and reciprocal the actual results showed a percentage of 18.5 and 19.2 respectively. This fluctuating variation was observed in the different crosses, and while time did not permit the duplicating of results to determine the exact cause it might be mentioned that the standard parent may be responsible for this variation, since the dwarf parent was the same in each case.

TABLE IV.

COMPARISON OF PARENTAL, F_1 AND F_2 GENERATIONS UNDER GREENHOUSE CONDITIONS.

Name.	Average Number Fruits.	Total Yield Ounces.	Ounces per Fruit.
Dwarf Stone x Prosperity F_1	14	45	3.2
Dwarf Stone x Prosperity F_2	13	42	3.2
Prosperity x Dwarf Stone F_1	14	50	3.6
Prosperity x Dwarf Stone F_2	13	36	2.7
Prosperity	13	34	2.6
Dwarf Stone	11	38	3.5
Dwarf Stone x June Pink F_1	17	43	2.5
Dwarf Stone x June Pink F_2	14	40	2.8
June Pink	6	23	3.9
Dwarf Stone x Bonny Best F_1	15	50	3.3
Dwarf Stone x Bonny Best F_2	17	51	3.0
Bonny Best	10	33	3.3
Earliana x Dwarf Stone F_1	10	44	3.3
Earliana x Dwarf Stone F_2	11	35	3.1
Dwarf Stone x Earliana F_1	15	48	3.2
Dwarf Stone x Earliana F_2	13	40	3.0
Earliana	15	37	2.4
Comet x Dwarf Stone F_1	17	49	2.8
Comet x Dwarf Stone F_2	12	35	3.0
Comet	20	47	2.3
Stone x Dwarf Stone F_1	14	44	3.1
Stone x Dwarf Stone F_2	12	40	3.3
Stone	12	35	3.0
June Pink x Dwarf Stone F_1	11	23	2.0
June Pink x Dwarf Stone F_2	13	38	2.9

YIELD.

By the examination of Table IV, where the comparison of the yields of the parental, F_1 and F_2 generations are made, the F_1 cross yielded more fruit, both the individual plants as well as the total yield, than did either parent. Considering the standard plants of the F_2 generation the yields were slightly less than the F_1 , and in both cases the sum total yield as well as the number of fruits set was decidedly in favor of the F_1 cross. From a commercial standpoint, it would be practical to grow F_1 generation plants in order to get a more vigorous growth which in turn will produce greater yields.

In every case the cross was more vigorous and thrifty than was either parent, which probably gave the increased yields. It was also found that the second and third generation plants decreased in yield, some only slightly while others equal to, if not below the parent.

FURTHER DATA SUBSTANTIATING THE INFLUENCE OF CROSSING ON INCREASING THE YIELD OF TOMATOES.

BY RICHARD WELLINGTON, *Experiment Station, St. Paul, Minn.*

(This address is to be published in a bulletin by the Minnesota Experiment Station.)

STUDIES IN LETTUCE BREEDING.

BY C. E. DURST, *University of Illinois, Urbana, Illinois.*

The lettuce breeding experiments reported herewith were begun at the Illinois Agricultural Experiment Station during 1913. The well-known forcing variety Grand Rapids was crossed with the heading varieties May King and Big Boston, the idea being to develop, if possible, a better forcing variety of head lettuce. The Big Boston and May King were also crossed with the wild form *Lactuca Scariola* that is so common in the Middle West. This paper deals more particularly with the crosses first mentioned, but certain points in connection with the latter will be presented also.

In making the crosses, the pollen was washed from the stigmas by syringing with water, substantially as described by Oliver in Bulletin 167 of the Bureau of Plant Industry, United States Department of Agriculture, though certain modifications were adopted to meet the case at hand.

May King and Big Boston have a pronounced heading habit. Grand Rapids is of the distinctly "leaf" or non-heading type. In the crosses May King (female) x Grand Rapids (male) and Big Boston (female) x Grand Rapids (male) the F_1 generation was intermediate in heading habit. The plants were conspicuously uniform in this, as well as in all other respects. They were also considerably larger in size than the parental types. In the F_2 generation, a graduation in heading habit was secured which extended from one parental type to the other. It was possible to divide these, arbitrarily, into six classes. Few individuals were obtained which resembled either parental type, most of the population ranging between these two extremes. In the F_3 generation of the cross Big Boston x Grand Rapids, some families bred true to one or another type, while others produced a mixed population, which was what would be expected. No F_3 plants of the other crosses have been grown to date. The heading habit in lettuce is apparently inherited according to the theory of multiple factors with incomplete dominance.

Definite measurements were taken of the length and width of three of the largest leaves at the base of each plant in the crosses May King x Grand Rapids and Big Boston x Grand Rapids. Some idea of the shape of the leaves was obtained by dividing the average of the figures for length by that for width. As very few F_1 plants were grown, no measurements were secured for this genera-

tion. The means for length and width were undoubtedly higher than for the parents, but it is not thought that the coefficients of variability were greater. In the F_2 generation the means for length were higher than those for either parent, while in leaf width the means were about at the midpoint between the two parents. The mean of the relation of width to length was lower in the F_2 plants in both crosses than in any of the parents. The coefficients of variability were much greater in all cases in the F_2 generation than in the parental types, which fact may be taken as proof that segregation of the factors controlling leaf length, width, and shape, took place. No measurements were taken of the F_3 plants, but that some families were breeding pure for a certain size and shape of leaf, while others produced a mixed population, was plainly apparent by inspection. Leaf length, width, and shape in lettuce appear to be inherited also according to the theory of multiple factors with incomplete dominance.

Big Boston and May King carry a red or bluish-red pigment which sometimes becomes so pronounced when a period of cool weather occurs just before cutting time, that the product is discounted in value on the market. Grand Rapids is free from this pigment. The presence of this character is allelomorphic to its absence, the former being dominant. Inheritance in this case occurs in simple Mendelian fashion. Heading types breeding pure for the absence of pigment were obtained in the F_3 generation of the cross Big Boston x Grand Rapids. As already stated, no F_3 plants of other crosses have been grown.

The seeds, or achenes, of Big Boston and May King are grayish-white. Those of Grand Rapids and the wild *Lactuca scariola* are brownish-black. In the F_1 generation all seeds were black. In the F_2 generation practically a 3:1 ratio was obtained when May King was crossed with either Grand Rapids or the wild form. When Big Boston was crossed with the same two, a 9:7 ratio appears to have resulted in both cases. In other words, it appears that one pair of factors is concerned for seed color when May King is crossed with Grand Rapids or the wild form, and that two factors are involved when Big Boston is substituted in its place. On account of the wet weather the past season, many of the plants died from disease before producing seed, consequently, the number of individuals involved is not large enough to permit final conclusions. The results point so strongly in the directions outlined above, however, that it is believed those statements represent the truth in the matter. Whether or not such is actually the case, only further investigation can determine.

The wild *Lactuca scariola* is densely setose or spiny on the underside of the midribs. A few smaller spines are also present on the lower epidermis. Big Boston and May King are destitute of spines, except for a few very inconspicuous ones near the bases of the midribs.

In the crosses between the wild form and Big Boston or Grand Rapids, all plants in the F_1 generation were spiny.

In the F_2 generation an almost exact 3:1 ratio was secured when Big Boston was crossed with the wild form, but what seems to be a 9:7 ratio was the result when May King was crossed with the wild form. One pair of allelomorphs is apparently involved in spine inheritance when Big Boston is crossed with the wild form, while two pairs seem to be involved when May King is used.

As with respect to color, a single pair of allelomorphs seems involved in one case and two pairs in the other, though in contrast to the case of seed color the varieties Big Boston and May King are reversed in regard to which one carries the one or the two pairs.

As to the adaptability of the hybrids for forcing purposes, the original object of the experiment, no data have yet been secured. On account of limited greenhouse facilities the heading types will first be fixed on the outside, after which they will be tested under glass.

Other matters are under study, but insufficient data have been collected to permit a report at this time.

INVESTIGATIONS IN CANNING SWEET POTATOES.

By T. H. McHATTON, *University of Georgia, Athens, Georgia.*

The basis of this report is a thesis of Mr. R. E. Blackburn which was presented to the faculty of the University of Georgia in partial fulfillment of the master's degree from that institution. Two years were devoted to this work in the horticultural laboratories.

A great number of inquiries concerning the best methods of canning sweet potatoes, coupled with the fact that Georgia is the largest sweet potato producing state, led us to study this problem. Some three or four years ago there were one or two successful sweet potato canning establishments in Georgia; but owners of these establishments refused to give us any information, and treated as trade secrets the methods they followed, therefore, the department began its investigations.

It is probable that the first canned sweet potatoes were put up by Knowles & Anderson, of New Jersey, in 1885. It is certain that during the last ten years the sweet potato canning industry has increased 417 per cent and that the value of canned sweet potatoes at the present time is several hundred thousand dollars, with an increasing demand that is not being filled. Through correspondence we found many concerns going out of business, mainly because sweet potato canning was not as profitable as they had expected, due to the trouble in keeping down swells. Letters from canneries all over the United States showed a variation in methods used, running from 3 hours in the open process, with swells processed on the second day, to 70 minutes in a closed process at 250 degrees F., or 15 pounds steam pressure.

Considerably more than 2,000 cans were put up in the laboratory. Jars were used to a great extent, as changes in the product could be easily noted. The period of cooking the sweet potatoes before putting into cans was varied from 20 to 90 minutes; the time

of exhausting from 0 to 30 minutes; the open process from 1 to 5 hours. All the open process work from 1 to 4 hours was unsatisfactory, but when processed from 4 to 5 hours a fair degree of success was obtained. Such a long process was considered impracticable on account of expense. A period of 40 to 45 minutes was found to be the best length of time for cooking sweet potatoes before peeling them; and in further work this time was used, unless the potatoes were peeled with lye. Peeling with lye is used by some concerns. A solution of potash is made up strong enough to take the skin off in about 4 minutes. This solution is kept boiling, the potatoes are removed from it and placed immediately under a strong spout of cold water. This removes the skins. The potatoes are then transferred to a receptacle of hot water where they remain from 10 to 15 minutes before being transferred to another receptacle and cooked.

In experiments with intermittent processing the time of exhaust was varied from 0 to 30 minutes, and processing from 1 to 3 hours on 2 and 3 successive days. These methods gave fairly good results as far as keeping was concerned, but produced a very poor color. For that reason the intermittent processing for canning sweet potatoes was discarded.

In pressure work the sweet potatoes were cooked from 40 to 45 minutes; the exhaust varied from 0 to 30 minutes; the time of process from 1 to 3 hours; and the pressure from 5 to 15 pounds. This work gave good results and fair color.

The next experimental work was a study of the color of the final product. In this work potatoes were cooked and peeled by hand, as well as peeled with strong lye. The intermittent process was used on 3 and 4 successive days, as well as pressure at 5, 10 and 15 pounds. The color produced by intermittent process was "poor" to "fair" in all instances, and "fair" to "good" in the pressure tests when the product was allowed to cool slowly. When the retort was filled with cold water immediately after pressure processing was over, the colors obtained were "good" to "excellent." The amount of exhaust did not seem to have much to do with color, though some of the commercial canners state that unless sweet potatoes are exhausted the air in the can will cause a darkening of the product. It is generally accepted that to obtain good color in canning sweet potatoes, they must be protected from the air as much as possible from the beginning of the canning operations until they are finished; this held true in our work.

At the end of the experiments the following method of canning sweet potatoes was recommended to the canning club agents of Georgia, as well as to others interested in this business.

In order to obtain a good commercial product which will keep and have a good color, the sweet potatoes should be cooked from 40 to 45 minutes before being peeled, or peeled with hot lye. After peeling, pack into cans as tightly as possible; exhaust for a few minutes; seal and process at 10 pounds pressure, or 240 degrees F., for from 70 to 75 minutes, and cool immediately by the introduction

of cold water into the retort just as soon as processing is over. The best commercial results will be obtained under these conditions.

One of the points to receive attention in this work was the influence of processing on the sugar content of the product. It was hoped to study this question in relation to the various methods of processing. The chemical analysis could, of course, have been made, but the laboratory was not equipped for this work, and it was decided, therefore, to use the polariscope. The solutions for testing were made up by the accepted method; that is, using 26.048 grams of the potato grated to 50 c. c. of water heated to 55 or 60 degrees C. Cool for several minutes; heat again; clarify with lead subacetate, or aluminum cream, or both; filter and make up to 100 c. c. with distilled water. To determine the inverted sugar 50 c. c. of this material were taken and freed of the lead by precipitation; 25 c. c. of water were added, and while heating to 70 degrees C., 5 c. c. of HCl, 38.8 per cent, were added. The solution was allowed to stay at 70 degrees C. from 7 to 7½ minutes, and cooled quickly to 20 degrees C., then diluted to 100 c. c. As far as results obtained from the polariscope analyses of direct and inverted sugars are concerned, we must report absolute failure. The results would not check. The greatest trouble was in clarifying the solution and getting it filtered. Various kinds of suction filters were used, but it took some solutions as long as 2 days to filter once. The starchy content of the sweet potato is so great that it was found impossible to get solutions through filters in any reasonable time. There was also a great deal of trouble in clarifying solutions for polariscope work. The length of time required to carry on work with solutions brought in such a possibility of error, through evaporation, etc., that after several months' work along varied lines we gave up this method of trying to establish the influence of processing upon the sugars in the potatoes. This matter is reported simply to prevent others from trying these methods; and should this work be taken up again other methods of studying sugar content will have to be used, as the polariscope has proven to be a failure.

The most important piece of work done in regard to this sweet potato question was the investigation of spoiled cans. By inserting a note in the "Canning Trade," we received specimens of both swelled and sprung cans from 14 sources in 6 states. In none of the spoiled cans in the laboratory, several hundred of which we had during the beginning of our experiment, had we been able to locate a fungus or yeast as causing the trouble, but many of the cans had a peculiar odor. It was decided, therefore, to investigate the bacterial end of it. The media was made as follows:—100 grams of sweet potato chopped fine; 500 c. c. distilled water; put in 1,000 c. c. flask and heated to 55 degrees C. for 2 hours; filtered while warm and made up to 500 c. c. with distilled water. Dissolved 10 grams of agar in 500 c. c. of distilled water and filtered into 500 c. c. of sweet potato infusion, making 1,000 c. c. of sweet potato agar which was sterilized in the normal way. From the spoiled cans in our laboratory we isolated 2 bacteria, designated as number 1 and number 2.

Number 1 is described as follows:

Agar plate: rapidly spreading colony, thin, somewhat wrinkled, whitish, grayish when old, edge deeply fimbriate.

Agar stab: growth dense over surface, and marked along the line of stab, uniform, and grows into the media.

Agar slant: growth becomes dense over surface, along the line of the smear the colony diffuses into the media slowly.

Gelatin plates, stab, and slant: rapidly liquified.

Potato plugs: for first few days growth is not seen, but gases formed, later growth becomes more evident and gas more plentiful; gas has characteristic odor of spoiled sweet potato cans.

Organism does not form indol, H_2S , tryptose, nor does it have any effect on methyl blue, though litmus is reduced. There is no butyric acid. The organism stains readily with the ordinary stains. No flagella were found. It is a spore forming bacterium; facultative aerobe; rods short and rounded at ends; species not identified.

Number 2 is described as follows:

Agar plates: colonies round, deep, dense, viscid, white, wrinkled, never spreading.

Agar stab: growth over surface slow, does not diffuse readily into media.

Agar slant: practically same as plate and stab.

Gelatin plate, stab, and slant: liquified immediately, more rapidly than number 1.

Potato plug: growth rapid, grayish white, apparent from the first, no gas, no odor.

Indol none, H_2S none, tryptose none, litmus reduced, butyric acid none. Staining did not show flagella; a spore forming bacterium; aerobe; rods straight; species unidentified.

As stated above, these were designated as bacteria number 1 and number 2, and came from laboratory material. The investigations of the spoiled cans sent in gave the following table:

Cans—Where Obtained.		Type of Bacteria.	Character of Spoilage.
A.	Florida	No. 2	springer
B.	West Virginia	No. 1	swell
C.	Virginia	No. 1 and 2	swell
D.	Delaware	No. 1	swell
E.	Virginia	No. 1 and 2	swell
F.	Maryland	No. 1	swell
F ₁	Maryland	No. 1 and 2	swell
G.	Delaware	No. 1 and 2	swell
H.	Virginia	No. 2	swell
I.	Virginia	No. 2	springer
B ₁	West Virginia	No. 1	springer
I ₁	Virginia	No. 1 and 2	swell
J.	Georgia	No. 1	swell
J ₁	Georgia	No. 1 and 2	swell

In this table capital letters have been used to designate different concerns sending in cans. Where a capital letter is used with a numeral below, it shows that the concern sent 2 cans showing the different types of spoilage. Where No. 1 appears alone the can was a "swell," and on opening it the unpleasant odor of spoiled sweet potatoes was noted. Where No. 2 appears alone, the can was a "springer." Sometimes No. 1 and No. 2 appeared together, and under these conditions the can swelled and had a characteristic odor. A glance at the table shows that No. 1 appears in 11 instances; No. 2 in 9 instances, and No. 1 and No. 2 together in 6 instances, and that both organisms are pretty well scattered over the whole sweet potato canning territory. No effort was made to classify or identify these bacteria, though we communicated with several laboratories in this country doing work along this line, but none of them were in a position to render us help. We feel, however, that it has been determined that the great cause of trouble in the sweet potato canning industry comes through the action of these organisms, either independently or combined, and that sweet potato canners will find it necessary to use high temperatures for a considerable length of time in order to produce a product reasonably free from swells and springers.

EXPERIMENTS IN THE USE OF MUCK OR PEAT SOILS IN GROWING GREENHOUSE CROPS.

By H. C. THOMPSON,

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In order to study the different types of muck or peat soils and to determine the value of such soils in growing greenhouse crops, the writer started a series of experiments in the fall of 1912. The experiments were carried on in greenhouses at the Arlington experimental farm, near Arlington, Virginia. This work is correlated with field studies which were made on the same muck deposits. The soil selected for the experiments the first year, was taken from a cultivated field in northern New Jersey. This soil is a good type of black muck and is representative of large areas of cultivated muck land in various sections of the North. For a number of years this soil had been used for growing celery, lettuce, and onions. It was in a good state of cultivation and well decomposed. During the second and third years the same type of soil was used and in addition to this, another type was secured from Michigan. The Michigan soil was taken from a field which had grown sugar beets and mint for a few years, and is representative of large areas in Michigan and neighboring states. This soil was not as well decomposed as the New Jersey soil and has not given as good results.

During the season of 1912-13, crops of lettuce, cauliflower, and tomatoes were grown on the New Jersey muck. The lettuce was grown on raised side benches which were divided into 8 equal plats,

5 feet 3 inches long and 3 feet 6 inches wide, the plats being run in duplicate sets. Cauliflower and tomatoes were grown on raised center benches in plats 5 feet 3 inches wide by 7 feet long. All of the mixtures were proportioned by volume.

In the experiments the first season the same mixtures were used for all of the crops and were as follows:

- Plat 1. Pure muck.
- Plat 2. $\frac{3}{4}$ muck, $\frac{1}{8}$ clay, $\frac{1}{8}$ sand.
- Plat 3. $\frac{1}{2}$ muck, $\frac{1}{4}$ clay, $\frac{1}{4}$ sand.
- Plat 4. Check $\frac{1}{2}$ clay, $\frac{1}{2}$ sand.
- Plat 5. Regular greenhouse soil ($\frac{1}{2}$ clay, $\frac{1}{4}$ sand, $\frac{1}{4}$ manure).
- Plat 6. $\frac{1}{4}$ muck, $\frac{1}{2}$ clay, $\frac{1}{4}$ sand.
- Plat 7. $\frac{1}{8}$ muck, $\frac{5}{8}$ clay, $\frac{1}{4}$ sand.
- Plat 8. $\frac{1}{2}$ muck, $\frac{1}{2}$ clay.

The mixture used in Plat 5 was the same material that was employed for general greenhouse work at Arlington Farm in 1912-13. It was not a first-class greenhouse soil, but had given fair results in general forcing work.

The muck soils used in the experiments and the greenhouse soil used in Plat 5 during 1912-1913 were analyzed for lime, potash, phosphorus, and nitrogen. These analyses are as follows:

	CaO	K ₂ O	P ₂ O ₅	N
Muck soil, per cent.	5.16	0.16	0.42	1.85
Soil of Plat 5	0.46	0.82	0.36	0.14
Michigan muck	4.05	0.26	0.27	2.15

From these analyses it will be seen that the muck soil was low in potash, fairly high in lime, and high in nitrogen. However, many muck soils show much more nitrogen than the two used in this experiment. The greenhouse soil was a fairly good garden soil, but rather low in nitrogen for a good greenhouse soil.

It should be borne in mind that the muck soil used in all of the experiments was untreated, and contained a large amount of moisture, while the manure used in Plat 5 was well rotted, and was composted with the soil. The mixtures containing muck were prepared a short time before the plants were set.

In growing lettuce the usual method was followed. The seed was sown in flats and the young plants were transplanted once before being planted in the bench where they were to mature. The variety of lettuce used in these experiments was the Grand Rapids.

The average yield per crop of six crops of lettuce grown on New Jersey muck is given in Table I.

TABLE I.

AVERAGE YIELD OF LETTUCE ON NEW JERSEY MUCK SOIL DURING
1912-13, 1913-14, AND 1914-15.

Plat.	No. Plants.	Weight lbs.
1	70	271½
2	70	25
3	70	23
4	70	4
5	70	21
6	70	191¼
7	70	131½
8	70	253¼

The above figures show that the highest yield was on the plat containing pure muck soil and that all of the plats containing 50 per cent or more muck gave higher yields than the regular greenhouse soil. In fact, during two years out of three the plat containing 25 per cent muck produced larger yields than Plat 5. The yield on all of the plats containing muck was very much lower in 1913-14 than in either of the other two years. The low yields in 1913-14 might have been due to loss of potash. The soil used the second year was from the original shipment of 1912 and had been exposed to the weather for a year when it was taken into the greenhouse. An analysis made at the end of the year showed a loss of a little more than half of the potash.

The yield of lettuce on the Michigan muck soil is given in Table II.

TABLE II.

AVERAGE YIELD OF LETTUCE ON MICHIGAN MUCK.

Plat.	No. Plants.	Weight lbs.
1	70	22
2	70	213¼
3	70	201½
4	70	111¼
5	70	261¼
6	70	191½
7	70	173¼
8	70	203¼

By comparing the results given in Tables I and II it will be seen that the New Jersey muck soil produced much better results than the Michigan muck, although the latter contained more potash and nitrogen than the former. The difference in yields on the two soils might have been due to the difference in stage of decomposition. The Michigan soil had not been under cultivation as long as the New Jersey soil and was coarser in texture.

CAULIFLOWER ON NEW JERSEY MUCK.

The cauliflower was grown in the same mixtures as the lettuce, but the plats of the former were twice the size of the latter. Each plat contained 24 plants at the beginning. Six crops of cauliflower were grown during the three seasons, 1912-13, 1913-14, and 1914-15, but the second crop of 1913-14 was planted so late that no heads were formed, and for this reason only five crops are considered in the records.

Table III gives the total yield of the five crops.

TABLE III.

TOTAL YIELD OF FIVE CROPS OF CAULIFLOWER ON NEW JERSEY SOIL.

Plat.	No. Plants.	Total Weight Pounds.	Weight Trimmed Pounds.	Marketable.		Not Marketable.	
				No.	Weight Pounds.	No.	Weight Pounds.
1	119	260 $\frac{3}{4}$	137	94	119 $\frac{1}{4}$	25	20 $\frac{1}{2}$
2	119	204	114 $\frac{1}{2}$	89	98 $\frac{1}{4}$	30	16
3	116	176	98	82	85 $\frac{1}{2}$	34	12 $\frac{1}{2}$
4	118	100 $\frac{3}{4}$	68 $\frac{1}{2}$	70	55	48	13 $\frac{1}{2}$
5	120	168	92 $\frac{1}{2}$	74	71 $\frac{3}{4}$	46	20 $\frac{3}{4}$
6	119	169 $\frac{1}{4}$	89	84	74 $\frac{1}{4}$	35	13 $\frac{3}{4}$
7	118	137	86 $\frac{1}{4}$	77	65 $\frac{1}{4}$	41	21
8	116	209	118 $\frac{1}{2}$	88	105 $\frac{3}{4}$	28	12 $\frac{3}{4}$

The average yield per crop is given in Table IV.

TABLE IV.

AVERAGE YIELD PER CROP OF CAULIFLOWER ON NEW JERSEY MUCK.

Plat.	No. Plants.	Total Weight Pounds.	Weight Trimmed Pounds.	Marketable.		Not Marketable.	
				No.	Weight Pounds.	No.	Weight Pounds.
1	23.8	52.15	27.4	18.8	23.85	5.0	4.10
2	23.8	40.80	22.8	17.8	19.65	6.0	3.20
3	23.2	35.20	19.6	16.4	17.10	6.8	2.50
4	23.6	20.15	13.7	14.0	11.00	11.0	2.70
5	24.0	33.60	18.5	14.8	14.35	9.2	4.15
6	23.8	33.85	17.8	16.8	14.85	7.0	2.75
7	23.6	27.40	17.25	15.4	13.05	8.2	4.20
8	23.2	41.80	23.7	17.6	21.15	5.6	2.55

The cauliflower plants were cut off at the surface of the ground and the whole mass was weighed, then the leaves were cut off and the heads trimmed back as for market. The trimmed heads were graded into marketable and not marketable grades.

An examination of Tables III and IV show that the highest total yield was on Plat 1 followed by Plats 8, 2, 3, 6, 5, 7, and 4 in the order named. The highest yield of trimmed heads was on Plat 1 and follows in the same order as for total weight of plants, except that Plat 5 ranks ahead of Plat 6 in the former. The highest yield of marketable heads was on Plat 1 followed by Plats 8, 2, 3, 6, 5, and 7 in the order named.

In order to find out if the soil was exhausted by two crops of cauliflower, it was decided to keep the soil used in 1913-14, for another year. The soil was left in the benches during the summer and allowed to dry out. At the beginning of the forcing season it was thoroughly watered and put in good condition, but no fertilizer was applied.

The yield of cauliflower on this old soil is given in Table V.

TABLE V.

CAULIFLOWER GROWN IN NEW JERSEY MUCK 1914-15 ON SOIL WHICH
HAD PRODUCED TWO CROPS IN 1913-14.

				Marketable.		Not Marketable.	
Plat.	No. Plants.	Total Weight Pounds.	Weight Trimmed Pounds.	No.	Weight Pounds.	No.	Weight Pounds.
1	24	29¼	17¼	18	14½	6	2¾
2	24	27¼	16	18	13¼	6	2¾
3	23	25¼	15¾	20	14½	3	1¾
4	23	8¼	5¼	0	0	23	5½
5	24	24½	14¼	16	11¼	8	3
6	24	18¾	11½	14	8¾	8	2¾
7	24	14¼	8	7	4	17	4
8	24	19¾	10¾	11	6¼	13	4

After producing the three crops of cauliflower this soil was fertilized at the rate of 1½ pounds to the plat of 4-8-10 mixture containing nitrate of soda, dried blood, bone meal and muriate of potash. The fertilizer was applied to the surface and thoroughly mixed with the soil before the plants were set. The yield of this fourth crop is given in Table VI.

TABLE VI.

CAULIFLOWER GROWN IN NEW JERSEY MUCK, FOURTH CROP ON SAME SOIL. FERTILIZER APPLIED FOR FOURTH CROP.

Plat.	No. Plants.	Total Weight Pounds.	Weight Trimmed Pounds.	
1	24	54	32 $\frac{3}{4}$	All
2	24	57 $\frac{1}{2}$	33 $\frac{3}{4}$	
3	24	52 $\frac{1}{2}$	28 $\frac{1}{2}$	
4	24	42 $\frac{3}{4}$	25 $\frac{1}{4}$	Heads
5	24	49 $\frac{3}{4}$	27	Were
6	24	50 $\frac{1}{4}$	32 $\frac{1}{4}$	
7	24	48	29 $\frac{1}{4}$	
8	24	56 $\frac{3}{4}$	35	Marketable

The figures given in the above table show that plant food was the main limiting factor, and that all plats produced fairly good yields when supplied with a complete fertilizer. The highest yield was on Plat 8, containing 50 per cent muck and 50 per cent clay, followed by Plats 2, 1, 3, 6, and 5 in the order named.

TOMATOES GROWN IN NEW JERSEY MUCK SOIL EXPERIMENT.

During the season 1912-13 tomatoes were grown on the same soil mixtures as were used for cauliflower and lettuce, but in 1913-14 the sand was left out of the mixtures containing one-half, or more muck, and Plat 8 contained a mixture of one-half muck, three-eighths clay, and one-eighth manure. The percentage of muck in all of the plats was the same in 1912-13 and 1913-14.

The average yields of the two crops of tomatoes is given in Table VII.

TABLE VII.

AVERAGE YIELD OF TOMATOES GROWN IN NEW JERSEY MUCK SOIL IN 1912-13 AND 1913-14.

Plat.	Weight Pounds.
1	58 $\frac{1}{4}$
2	59 $\frac{1}{2}$
3	59
4	38 $\frac{1}{2}$
5	52
6	50 $\frac{3}{4}$
7	45 $\frac{1}{8}$
8	61 $\frac{1}{2}$

The crop of tomatoes produced the second year was not as large as that grown the first year, except on Plat 5. Possibly the loss of potash due to leaching action of rains had some effect on the yields of plats containing muck soil. The highest yield for the two years was on Plat 8, followed by Plats 2, 3, 1, 5, 6, 7, and 4 in the order named.

The muck soil from Michigan gave better results in growing tomatoes than in growing either lettuce or cauliflower, but was not quite as good as the New Jersey soil.

The yield of tomatoes on Michigan muck is given in Table VIII.

TABLE VIII.

TOMATOES GROWN ON MICHIGAN MUCK SOIL.

Plat.	Weight Pounds.
1	48½
2	47½
3	49
4	26¼
5	49
6	39½
7	41
8	51

The results given in Table VIII show that all of the plats except number 4 gave a fair yield of tomatoes. Plat 8 gave the highest yield and Plats 3 and 5 produced the same amount of fruit. In other words, one-half muck in combination with clay gave the same yield as one-third well rotted manure.

ROSES IN NEW JERSEY MUCK SOIL EXPERIMENT 1913-14.

The roses grown in this experiment were Pink Killarney and White Killarney, and were propagated from greenhouse stock grown at Arlington Farm. The plants were pot grown and were set in the greenhouse benches in June and received the care ordinarily given roses. Records were kept by month beginning with October and ending with April.

The mixtures used in growing roses were as follows:

Plat 1. Pure muck.

Plat 2. $\frac{3}{4}$ muck, $\frac{1}{4}$ clay.

Plat 3. $\frac{1}{2}$ muck, $\frac{1}{2}$ clay.

Plat 4. Clay (CHECK).

Plat 5. Greenhouse soil (3 parts clay, 2 parts manure, 1 part sand).

Plat 6. $\frac{1}{4}$ muck, $\frac{3}{4}$ sand.

Plat 7. $\frac{1}{8}$ muck, $\frac{7}{8}$ clay.

The yield of blooms is given in Table IX.

TABLE IX.

YIELD OF BLOOMS IN NEW JERSEY MUCK SOIL, 1913-14.

Plat.	No. Blooms.	No. 1sts.	No. 2nds.
1	674	157	517
2	631	282	349
3	814	707	107
4	252	206	46
5	692	571	121
6	690	565	125
7	593	468	125

The blooms were separated into two grades. Those marked "firsts" were perfect blooms with stems over 6 inches long and those marked "seconds" were good blooms with stems under 6 inches long.

The best and largest blooms, the highest per cent of first grade and the largest number were produced on Plat 3, containing 50 per cent muck and 50 per cent clay. The foliage was heavier and of a darker green color on all plats containing 50 per cent or more muck than on Plats 4 and 5. The plants on Plats 1 and 2 were very vigorous and had to be pruned back a number of times during the season, but the buds were not as good as on the other plats. However, our work this season indicated that an application of commercial fertilizer would have remedied this trouble. Plat 6 containing 25 per cent muck produced about the same number of flowers as Plat 5 which contained 33 1-3 per cent manure.

CARNATIONS IN NEW JERSEY MUCK SOIL EXPERIMENT, 1913-14.

Carnations used in this experiment were propagated from greenhouse stock of Pink Enchantress. The plants were grown entirely in the greenhouse, being planted in the permanent beds early in the summer. The soil mixtures used for carnations were the same as those used for roses. The yield of blossoms is given in Table X.

TABLE X.

YIELD OF CARNATIONS ON NEW JERSEY MUCK, 1913-14.

Plat.	No. Flowers.	No. Good.	No. Split.
1	824	629	195
2	773	587	186
3	777	638	139
4	610	487	123
5	967	832	135
6	811	665	146
7	748	603	145

Good flowers were produced on all of the plats, but the highest yield of blossoms was on Plat 5, containing the regular greenhouse soil, followed by Plats 1, 6, 3, 2, 7, and 4 in the order named. Flowers of the best size and color and length of stem were on Plat 3. The stems on plats 1, 2, and 3 were heavier and longer than on Plat 5.

CONCLUSIONS.

While no definite conclusions are drawn, the results secured during the past few years indicate that a good type of cultivated muck soil can be used to advantage in growing greenhouse crops. The greatest value of muck soil in greenhouse work is for foliage crops such as lettuce, although cauliflower and tomatoes produced good crops on pure muck and on mixtures containing 25 to 75 per cent muck.

The best results in growing roses were secured on Plat 3 containing 50 per cent muck. The mixture containing 25 per cent muck and 75 per cent clay gave practically the same results as the regular greenhouse soil which contained 3 parts clay, 2 parts manure and 1 part sand.

Carnations did not produce as many flowers on any of the muck soil mixtures as on the regular greenhouse soil. The stems on the plants in the mixtures containing 50 per cent or more muck were longer and heavier than on the plants grown on the regular greenhouse soil.

The soil from Michigan did not produce as good results as the New Jersey soil, although the former contained more potash and nitrogen than the latter. The writer believes that the physical or mechanical condition of the soil has a great deal to do with its productive capacity. In other words, the stage of decomposition of muck soil determines, to a large extent, its value as a greenhouse soil.

The indications are that a good type of muck soil can be used as a substitute for a part or all of the manure in growing the crops used in these experiments, with the exception of carnations.

REPORT OF THE COMMITTEE ON SCORE CARDS (VEGETABLES).

BY W. W. TRACY, SR., *Chairman,*

United States Department of Agriculture, Washington, D. C.

(The committee made a lengthy report and after a short discussion it was decided to have a mimeograph copy sent to each member pending action on the report at the next annual meeting.)

REPORT OF COMMITTEE ON FLORICULTURE.

By E. A. WHITE, *Chairman, Cornell University, Ithaca, New York.*

The last report of your Floricultural Committee was so complete that there seems little need of repeating the survey of the institutions offering courses or the outlines of the courses recommended. Since that report was written, however, there have been some changes and developments which should be noted.

Better facilities for teaching floriculture have been provided at several agricultural colleges. Among these, new ranges have been built at Ohio, Iowa and Indiana, while extensive additions to glass-house areas for teaching have been made at the University of Illinois and at Cornell.

In institutions where instruction in floriculture is given, there has been a strengthening of the courses as the needs of students have become more evident. There are few precedents in floricultural instruction, therefore courses have been passing through a period of evolution. There has been a marked improvement in the nature of the work given.

In the last report of your committee, attention was called to the fact that there were no suitable floricultural textbooks. In an endeavor to meet this need, the chairman of your committee prepared during the past year a book of this character, "Principles of Floriculture." In the preparation of this book it was aimed to make a general survey of the principles which govern all phases of flower production; therefore, of necessity, many details were omitted. The book was designed to meet the needs of smaller institutions of learning where only a general course in floriculture is given in connection with other horticultural courses. The flower-growing industry changes rapidly and almost constant revision is necessary to keep a textbook of this sort up-to-date. In those institutions where special courses in floriculture are given, there is no doubt in the minds of your committee that the lecture system, supplemented by required outside reading, is the best method of giving instruction.

Your committee wishes to emphasize the importance of requiring students intending to specialize to first have a thorough knowledge of chemistry, soils and fertilizers; also botany in all its phases, especially plant physiology and plant pathology. Unless these subjects be mastered before the more technical courses are given, the students have little ability to master the subjects of flower and plant production. A business training is also essential, and every student of floriculture should have courses in costs and accounting. A certain amount of farm practice also makes him more efficient.

It is the opinion of the committee that instructors in floriculture should come in contact early in the courses with the students intending to specialize in floriculture so that a definite program may be mapped out for the whole course. Experience has proved that too frequently a student does not decide until his junior year, or

later, that he wishes to specialize in floriculture. His fundamental studies have not been of a nature to fit him for efficient work, and the results are unsatisfactory to both student and instructor.

The problem of the character and methods of laboratory work is a deep one. There should be a careful correlation between the work of the classroom and that of the laboratory. It is the opinion of your committee that laboratory exercises should not aim to make men proficient in the technique of greenhouse work, but should endeavor to emphasize and make clear to them the reasons for the scientific principles and methods discussed in lectures.

The problem as to how our men in floriculture shall get practical experience, is also a serious one. Our agricultural colleges are not equipped to give training such as men should have if they are to take positions of a practical nature. The most efficient students are those who have had experience in greenhouses before coming to college. The number of these students, however, is limited. Our problem is in getting practical experience for these students who have had little or no training. It is our opinion that young men can get this experience nowhere better than in an up-to-date commercial range where their work is supervised by a broad-minded, successful florist. The great difficulty is to find such places for young men. Many successful florists do not want to be bothered with students in their ranges, and it is, of course, of little or no value for students to be with a second-class grower. There is also a feeling among too many practical men that the competition which they are to meet later from the men they train will be detrimental to their personal interests.

There has, however, developed recently among practical florists a more optimistic feeling regarding education, and many are giving most friendly co-operation in the work. Another difficulty in training men in floriculture is due to the fact that during the vacation period of our agricultural colleges little is being done in greenhouses. This difficulty may be overcome, to a certain extent, by an adjustment of our courses to better meet our educational needs. For example, the introduction of the third or summer term at Cornell University has, in a measure, solved the problem. The College of Agriculture never closes for a long vacation. As soon as the spring term closes, the summer term begins and lasts until the fall term opens. Students who are specializing in floriculture are required to take at least one summer of theoretical work during their course, and to spend an equal time before graduation in practical work on some up-to-date commercial range. The time thus spent is worth more to the student than any amount of laboratory work at the college could possibly be. A full year of work before graduation would, however, be of far more value to students.

In our floricultural teaching, however, all the emphasis should not be laid on commercial phases of the subject. Practically all institutions where horticulture is taught, are equipped to give strong courses in garden flowers and amateur flower growing. There is a constantly increasing demand for work of this nature,

and more emphasis should be laid on this valuable branch of the work. This course is especially important in these co-educational institutions where subjects in home economics are part of the curriculum.

To develop strong courses in floriculture, there must be a spirit of co-operation among men engaged in teaching. If there could be frequent round-table discussions of topics vital to this subject in connection with a series of meetings such as this, much good would result. Your committee welcomes suggestions from men engaged in other lines of horticultural work, and especially from those men who are giving general courses in horticulture.

WEDNESDAY, DECEMBER 29, 1:30 P. M.

**THE EFFECT OF CERTAIN MINERAL FERTILIZERS UPON
STRENGTH OF WOOD IN THE PEACH TREE.**

By C. A. McCUE, *Experiment Station, Newark, Delaware.*

Several years ago the Delaware Experiment Station began a long-time experiment with peaches with the object in view of learning, if possible, the effect of certain plant food elements upon the physiology of the peach. The variety used was Elberta and six hundred trees were planted, comprising twenty-four blocks of twenty-five trees each. Each block has received different plant food treatment. The fertilizers used have been confined to nitrate of soda, muriate of potash and acid phosphate. Each plot has been treated annually with certain definite fertilizers.

When this orchard was seven years old it was found necessary to give it a very severe pruning and many large limbs were removed from the trees. The removal of these limbs furnished the opportunity to make a preliminary study of the effect of nitrogen, potash and phosphoric acid upon the strength of wood.

Two of my senior students, Mr. Albert Shaffle and Mr. L. G. Gibney, were assigned the task of securing the necessary data. The number of pieces of wood large enough for testing, that it was possible to secure from each fertility block, was necessarily limited and the results obtained can only be considered as of a preliminary nature. The large limbs secured ranged from 1 $\frac{1}{4}$ inches to 1 $\frac{3}{4}$ inches in diameter. These limbs were cut into 14-inch sections, taking only one section from each limb. In this way five sections were secured from each fertility block. These sections were carefully numbered, air dried for several weeks, and then placed in steam drying oven where they remained for a period of about two weeks. Moisture tests were not made. Each stick was then sawed so as to form a square cross section. Some pieces squared $\frac{3}{4}$ inch, some $\frac{7}{8}$ inch, and some 1 inch. Owing to crooks and occasionally knots, it was necessary to reject several sticks. The squared pieces were then tested for bending and crushing strength upon a 30,000-pound Olsen testing machine. The bending test was made first and the crushing tests were made with blocks 1 inch long cut from

the end of the squared pieces. The results obtained for both crushing and bending strength were calculated to a common basis of 1 square inch cross section. The average strength of wood for each fertility block was then taken.

The following table gives the number of the block. The fertilizer treatment given, the number of test sticks from each block, the bending strength and crushing strength obtained on each block and the ratio between crushing and bending strength.

TABLE I.

Block.	Treatment per Acre.	No. of Sticks Tested.	Average Lbs. Required to Bend.	Average Lbs. Required to Crush.	Ratio.
1	50# K ₂ O *	3	461	6867	1:14.9
3	100# K ₂ O	5	504	6920	1:13.7
4	50# P ₂ O ₅	3	480	6570	1:13.5
6	100# P ₂ O ₅	3	540	7060	1:13
8	50# P ₂ O ₅ + 50# K ₂ O	3	445	5880	1:13.2
9	50# N	3	540	6312	1:11.7
11	50# N + 50# K ₂ O	5	545	6238	1:11.4
12	50# N + 50# P ₂ O ₅	5	646	6872	1:10.6
13	50# P ₂ O ₅ + 100# K ₂ O	3	632	6732	1:10.7
14	50# N + 50# P ₂ O ₅ + 50# K ₂ O	5	720	7139	1: 9.9
15	100# N + 50# P ₂ O ₅ + 50# K ₂ O	4	664	6761	1:10.2
16	100# N + 50# K ₂ O	5	587	6357	1:10.8
17	100# N + 50# P ₂ O ₅	4	639	6730	1:10.4
19	50# N + 50# P ₂ O ₅ + 100# K ₂ O	5	564	6519	1:11.5
21	50# N + 100# P ₂ O ₅ + 50# K ₂ O	3	617	6767	1:11
22	50# N + 50# P ₂ O ₅ + 150# K ₂ O	5	704	6636	1: 9.4
23	150# N + 50# P ₂ O ₅ + 50# K ₂ O	4	706	7004	1: 9.9
24	50# N + 150# P ₂ O ₅ + 50# K ₂ O	1	678	6828	1:10.1
	Checks No Treatment	2	620	6738	1:10.7
	Total	71	597.4	6665.5	1:11.15

* # = Pounds.

A study of Table I apparently throws but little light upon the strengthening or weakening effects of the different treatments. We had expected to find that nitrogen would weaken the strength of wood yet, we find Block 9, where nothing but nitrogen has ever been used, as strong as, or even stronger than, those blocks where potash or phosphoric acid alone has been used. Block 23 which has been heavily over-fertilized with nitrogen has with but one exception given the strongest bending strength and with but two exceptions the strongest crushing strength. Potash alone and phosphoric acid

alone appear to give a weak bending strength, yet their crushing strength is as high as or higher than that where a complete fertilizer has been used. Phosphoric acid combined with nitrogen gives a stronger wood than does potash combined with nitrogen, as is shown by comparing Block 11 with Block 12, and Block 16 with Block 17. The application of any element alone tends to increase the ratio between bending and crushing strength at the expense of bending strength. A normal supply of all three elements, without starvation or over supply of any one, seems to give the greatest strength of wood as is shown in Block 14.

Table II, III and IV compare the average strength of wood in blocks having each element in its fertilizer with the average strength of those which do not have the element.

TABLE II.

POTASH.

With Potash.			Without Potash.		
Bending Strength.	Crushing Strength.	Ratio.	Bending Strength.	Crushing Strength.	Ratio.
600 lbs.	6650 lbs.	1:10.8	569 lbs.	6537 lbs.	1:11.1

This gives a bending strength of 31 pounds and a crushing strength of 113 pounds in favor of potash.

TABLE III.

NITROGEN.

With Nitrogen.			Without Nitrogen.		
Bending Strength.	Crushing Strength.	Ratio.	Bending Strength.	Crushing Strength.	Ratio.
634 lbs.	6680 lbs.	1:10.5	510 lbs.	6671 lbs.	1:13

This table shows a bending strength of 124 pounds and a crushing strength of 9 pounds in favor of nitrogen.

TABLE IV.

PHOSPHORIC ACID.

With Phosphoric Acid.			Without Phosphoric Acid.		
Bending Strength.	Crushing Strength.	Ratio.	Bending Strength.	Crushing Strength.	Ratio.
618 lbs.	6730 lbs.	1:10.9	527 lbs.	6537 lbs.	1:12.4

This table shows a bending strength of 91 pounds and a crushing strength of 193 pounds in favor of phosphoric acid.

Tables V, VI, and VII compare the average strength of wood in blocks which have two elements in the fertilizer treatment with the average strength of those having neither of the two elements applied.

TABLE V.

POTASH AND NITROGEN.

With Potash and Nitrogen.			Without Potash and Nitrogen.		
Bending Strength.	Crushing Strength.	Ratio.	Bending Strength.	Crushing Strength.	Ratio.
566 lbs.	6298 lbs.	1:11.1	510 lbs.	6815 lbs.	1:13.4

Table V shows a gain in bending strength of 56 pounds per square inch by using potash and nitrogen in combination over the use of phosphoric acid alone, and a gain in crushing strength of 517 pounds per square inch by using phosphoric acid alone over the use of potash and nitrogen in combination.

TABLE VI.
PHOSPHORIC ACID AND NITROGEN.

With Phosphoric Acid and Nitrogen.			Without Phosphoric Acid and Nitrogen.		
Bending Strength.	Crushing Strength.	Ratio.	Bending Strength.	Crushing Strength.	Ratio.
643 lbs.	6801 lbs.	1:10.6	486 lbs.	6894 lbs.	1:15.0

Table VI shows a gain in bending strength of 157 pounds per square inch, and a loss of crushing strength of 93 pounds per square inch by using a combination of nitrogen and phosphoric acid as compared with potash alone. One of the most striking features of all brought out by this table is the great increase in ratio between bending and crushing strength brought about by leaving nitrogen and phosphoric acid out of the fertilizer. This would indicate the use of potash alone has a weakening effect upon the bending strength of the peach, making the wood brittle. Van Slyke in "Crops and Fertilizers" says that when potash is lacking a brittle wood will result. Table V offers a slight support to this statement, but Table VI would indicate that a brittle wood will more likely result when phosphoric acid and nitrogen are lacking and potash is present in an abundant supply. A glance at Block 22 in Table I would seem to indicate that very small amounts of nitrogen and phosphoric acid are needed to remedy this apparent weakening effect of potash on bending strength. If there is no nitrogen or phosphoric acid starvation; over-feeding with potash will tend to lessen rather than increase the ratio between bending and crushing strength of wood in the peach.

TABLE VII.
POTASH AND PHOSPHORIC ACID.

With Potash and Phosphoric Acid.			Without Potash and Phosphoric Acid.		
Bending Strength.	Crushing Strength.	Ratio.	Bending Strength.	Crushing Strength.	Ratio.
539 lbs.	6306 lbs.	1:11.7	580 lbs.	6575 lbs.	1:11.3

A study of Table VII shows that a fertilizer which contains only potash and phosphorus gives a bending strength of 41 pounds per square inch less than one which contains no potash or phosphorus and that there is a difference in crushing strength of 269 pounds in favor of the fertilizer containing only nitrogen.

In this case the check blocks have been figured in with those having been fertilized with neither potash or phosphoric acid. If these are omitted a slightly different result is obtained. With the check blocks out there is a difference of only one pound in bending strength and a difference of only six pounds in crushing strength in favor of the nitrogen block.

A study of Blocks 11, 12, 16 and 17 seems to throw a little light upon the effect of doubling the nitrogen fertilizer when used in connection with potash or phosphoric acid. When nitrogen and potash alone are used, doubling the amount of nitrogen increases the bending strength by 42 pounds and the crushing strength 119 pounds. Where nitrogen and phosphoric acid alone are used, doubling the amount of nitrogen *decreases* the bending strength by 7 pounds and the crushing strength by 142 pounds.

There seems to be some confirmation of the results found by Kissel* in certain grains. Kissel found that phosphoric acid strengthened cell walls. He also says that nitrogen reduced the thickness of the cell walls. If this should produce a corresponding weakening of strength of wood structures, it is not apparent in our work with the peach.

One fact that does seem to stand out in our results is that for peach wood the normal ratio between bending strength and crushing strength probably lies somewhere between 1:10 and 1:11.

A detailed study of the results of this experiment fails to throw very much light upon the influence of nitrogen, potash, and phosphoric acid in strengthening or weakening wood structures. The number of sticks tested was too small to make the results conclusive. Almost as much variation was found in strength of sticks from any one block as in the averages for the different blocks. While in a general way the results are negative they seem to indicate that no great stress can be laid upon fertilizing for strength of wood. The fertilizer that is so balanced as to give the most healthy growth will produce the strongest wood. The writer believes that even greater differences in strength of wood in the peach can be obtained by different pruning methods than were obtained by different fertilizer treatments.

SOME PECULIAR FORMS OF WINTER INJURY IN NEW YORK STATE DURING THE WINTER OF 1914-15.

By W. H. CHANDLER, *Cornell University, Ithaca, New York.*

In the spring of 1915 there was observed in some of the orchards around Ithaca a form of winter injury that was new, at least to me. While the normal bloom of peach trees was about May 6 to 13, certain trees of the variety Chili (Hills) in the orchard of Mr. T. H. King, of Trumansburg, were not yet in bloom on May 25. The same phenomenon was observed with Carman and

* Ber. Oberhess. Gesell. Nat u Heilk Gressen N. ser. Naturh Abt. 1, 1904-1906. Also Experiment Station Record Vol. 19, page 834.

with several other varieties in the orchard of the Department of Pomology, New York State College of Agriculture. While the normal bloom was May 6 to 13, bloom was still coming out after May 29. This phenomenon was observed in certain other orchards, particularly that of Mr. John Boardman, of Trumansburg. It should be mentioned that in New York the blooming of peach trees and of the other fruit trees varies much less than it does in the South, and such a difference in blooming time is remarkable. An examination of these blooms showed that there had been winter injury to the pith of the bud and even to the pith of the twig at the base of the bud. There was also some slight injury to the xylem, and some to the cortex, but very little. This phenomenon of late starting was observed also with leaf buds, the differences being about the same as those for fruit buds and the same injury was to be observed. Trees showing this injury were watched through the summer of 1915. A normal crop of fruit was set and it ripened, generally, at the same time as the fruit of the trees that did not show the injury. Generally, by the middle of the summer no difference was to be observed between the growth on injured trees and those that had started normally, except that the leaves looked younger and in some cases the growth continued a little later. A few trees showed a reduced vitality throughout the season, and the fruit did not ripen normally.

In this connection, it should be said that, usually, when peach buds are exposed to low temperature the first tissues to be killed are the flower parts in the bud. If the temperature goes still lower, the pith of the bud may be killed and the pith of the twig at the base of the buds much as that observed above. These last tissues, then, while tender are normally more hardy than the flower parts of the bud. The only explanation of this exception that could be found was in the nature of the summer of 1914 and the time of the freeze.

During the summer of 1914, the rainfall for Ithaca was: For May, 0.20 inches above normal (this rainfall, however, was in the early half of the month); for June it was 0.87 inches above normal; for July it was 1.86 inches below normal; and for August it was 2.86 inches above normal. In other words, the growing conditions were not very favorable until in August, when the rainfall was great. There was a rather marked tendency for late growth which was encouraged by the trees having practically no crop during that summer. The only marked low temperature of the winter was on December 26, when the temperature fell to 9 degrees below zero F. I have observed in freezing tissues of trees in a number of years that the flower parts of the bud reached maturity somewhat more rapidly than other tissues of the twigs. The explanation of this killing, then, seems to be lack of maturity.

In the same year, in the orchard of Mr. E. E. Morrell of Kinderhook, pear trees showed the same late starting. Injury in this orchard was more serious, however, and many trees were so injured that there was no recovery. An examination of the tissue

of the trees showed much the same injury as that in the peach trees, though all gradations of injury were to be found. In the case of some only the pith of the bud and some cortex and xylem showed injury while in the case of the others there was injury throughout the spurs and in still others the injury covered the whole twig or large portions of the tree. Where the injury did not cover all of the spur the trees showed some recovery, but in no case was it as marked as in the case of the peach trees. Weather conditions during the previous summer tend still further toward explaining this injury. The orchard was in a very sandy soil that is not retentive of moisture and it was not cultivated. The precipitation records for Albany, the nearest station to Kinderhook, were as follows: In May, 0.68 inches less than normal; in June, 2.17 inches less than normal; in July, 1.65 inches less than normal; and in August, 1.34 inches above normal. In other words, during the early part of the season moisture conditions were very unfavorable for growth. These conditions were made worse by lack of cultivation and by the unretentive nature of the soil. Then, in late July and August, moisture conditions were very favorable for growth. It is evident that a new activity began late and that the weak trees were not in a normal condition of maturity when the early winter freezes came. Orchards where the cultivation was done very late showed something of the same injury. In an old apple orchard belonging to a Mr. Mitchell at Kinderhook, many of the trees showed crown rot following this winter of 1914-15, though the temperature had not been very low. This, also, seems to be explained by the unfavorable growth conditions early in the season and the wet August, resulting in late cambium growth. In the case of old trees this region around the base of the trees is the last to become resistant. It seems highly possible that if these orchards had been so treated as to insure good growth early in the season, they would have been more nearly in a normal condition of maturity when winter began than they were with the very unfavorable growth conditions early in the season.

Any one going from one of the central states, like Missouri, into New York will be impressed with the importance of maturity in avoiding winter injury. In studying the question of winter injury for ten years in Missouri, I have never observed a year when even with young peach trees maturity was a very important factor. The growing seasons are long enough so that the trees generally mature well. However, in New York, the growing season being much shorter, the degree of maturity seems to be the most important factor in determining the amount of winter injury. Not uncommonly do we have pear spurs sent in to us where the thick portion is killed by the winter while the normal twigs show no injury. It seems certain, then, that this thickening process has taken place late in the season and the tissue has not reached sufficient maturity before severe freezing has occurred.

In attempting to grow pecans at Ithaca, we planted a number of varieties in the spring of 1914. These did not start growth until

late and practically every tree was killed by freezing before October 31, when the lowest temperature recorded was 26°F., though it is probable that the temperature in this orchard had been somewhat lower. Those that were not killed by October 31, were killed a few days later by a temperature of 23°F. Yet, young trees of the same varieties purchased from an Indiana nursery and planted in the fall of 1914 came through the winter in excellent condition. On account of fall planting these trees made an early start in the spring of 1915 and have so far gone through all freezes without injury though the temperature went to 2°F. on December 12.

SOME RESULTS IN THE BREEDING OF SMALL FRUITS.

By R. D. ANTHONY, *Experiment Station, Geneva, New York.*

In 1913 Mr. Richard Wellington presented before this Society a preliminary report of some raspberry breeding which was begun in 1910 at the Experiment Station at Geneva, New York. Certain phases of this work have now reached a stage when another report seems justifiable. The writer also wishes to discuss some results which have been secured in a study of sex in strawberries.

PURPLE RASPBERRIES.

The popularity of the purple raspberries has been increasing rapidly during the last ten years and in some regions they have largely supplanted the blackcaps. This has been due to their heavy production and their nearly complete immunity to the anthracnose which has been destroying the blackcaps. When we consider that but two varieties, Columbian and Shaffer, are responsible for this development and that these are but chance seedlings, we realize what an opportunity there is here for the fruit breeder. It is for this reason that the Experiment Station at Geneva has devoted considerable attention to this problem.

The first series of seedlings, which fruited in 1913, and which Wellington discussed in his report, included over fifty pure seedlings of Columbian and three hundred hybrids of the blackcap and the red raspberry. Since then over seven hundred hybrids have been fruited. A further study of these seedlings again leaves no doubt of the hybrid origin of the purple raspberry.

The pure Columbian seedlings have presented some interesting problems in their failure to break up in the F_2 generation as much as would be expected, most of the characters still showing intermediate types with very few cases where they approach at all closely to the parents. Recent correspondence with a private fruit breeder has led the writer to suspect that Shaffer will be found to possess a quite different gametic composition from Columbian and this suggests the advisability of selfing other purples.

In the crossed seedlings, June, a station seedling red raspberry, has been used as the male and two different blackcaps, Cumberland

and Smith No. 1, have been used as females. Practically every crossed seedling shows clear evidence of its hybrid origin. The Smith No. 1 seedlings were all purple though the color showed varying degrees of intensity but among the 289 Cumberland seedlings there were nine yellows which were intermediates in their bush type, and one yellow which might readily have been classed as a blackcap bush. None of the seedlings of either cross gave any indication of propagating by suckers.

An unusually large proportion of these crossed seedlings was very promising. The bushes were more vigorous than either parent and bore a heavy crop of large, firm fruit, somewhat later than the parents. Some were rather unattractive because of their dark color and dull look, caused by a thick pubescence, but many were a rich, glossy purple.

In the raspberry breeding, as in the grape breeding which the writer discussed last year, the value of a proper selection of parents is showing clearly. Of the hybrid seedlings from Cumberland as a mother, 12 per cent were saved as worthy of a second test. As breeding work goes, this was a high proportion, but it looks small when compared with 24 per cent which is the proportion of the Smith No. 1 seedlings saved. Although these two blackcaps ripen in nearly the same season, the Cumberland seedlings were about one week later.

For those wishing to breed purple raspberries, the best mode of procedure would seem to be to cross the most desirable reds and blacks rather than to attempt inter-crossing among the purples or to grow pure seedlings of any purple sorts. For such persons the chances of reward are excellent and, as results can be secured in from three to four years—a comparatively short time for the fruit breeder—this offers an attractive field.

.. DWARF TYPES IN RASPBERRIES.

Among the hybrid raspberries which fruited last summer and which are discussed above, some interesting dwarfs were noted. These were all found among the progeny of Cumberland, the Smith No. 1 seedlings all being standard plants.

These dwarf plants were very easily distinguished from the normal ones even when normal plants lacked vigor and made a low growth. There were nearly as many nodes on the dwarf canes as on the normal ones, but the internodes of the former were much shorter, sometimes not even a quarter of an inch long. Many of the leaves were very small but a few were nearly normal. The attachment of the petiole was very brittle and the leaves snapped off easily. The canes were thickly covered with soft spines while most of the standards had but few, stiff spines. Those dwarfs which were the most vigorous made a thick, bushy growth somewhat like the red raspberry yet they could not be said to form suckers. Many dwarfs were under a foot in height and the tallest were hardly two feet.

In the entire population there were forty-six dwarfs and one hundred seventy-eight standards. The dwarfing was accompanied by lack of vigor in most plants so that there was a higher percentage of mortality here than with the normal plants. Taking this into consideration, we see that this is reasonably close to a one-to-three ratio. Selfed seedlings of Cumberland have never been grown here, but several years ago a number of June seedlings was planted. An unusually dry summer destroyed the majority of them so that notes were not taken of individual plants and all not showing vigor were discarded. In this way no note was made of any dwarfs though they may have been present in considerable numbers. Pure seeds of June are now in the stratifying bed for next year's planting.

The factor for dwarfing is evidently one of rather rare occurrence as this is the first time it has been noticed among the station seedlings.

A CORRELATION IN LEAF AND FRUIT COLOR AMONG RASPBERRIES.

Over a hundred red raspberry varieties and seedlings fruited on the station grounds in 1915. In examining these it was found that on all plants the terminal leaves on the young canes had the upper surface more or less tinged with red. On some this tinging would extend down the cane for three or four leaves while on others only the first leaf would be colored. The gland-like tip of the leaf serrations on these young, expanding leaves, was red or tinged with red as were also the tips of the leaf serrations on the older leaves farther down the cane.

Yellow raspberries have originated on the station grounds in two ways; from crosses of red sorts and from crosses of the black-cap and red raspberry. In either case, the opening leaves on the young shoots lack this reddish tinge noticeable on the red raspberry and the glandular tips of the serrations of both the younger and older leaves are a light, greenish-yellow.

Among the hybrid purples these leaf marks are not as clearly distinguishable. In some of these the young leaves lacked the reddish tinge on the upper surface though in some it was nearly as marked as in the red raspberries. All the purples which were examined, however, did have the glandular tips of the serrations of these young leaves tinged red although on some only the serrations nearest the apex showed this. The purples also showed a greater tendency for these markings to vary on different canes on the same plant. On the older leaves of all the purples the gland-like tip of the serrations was red and this was the most easily determined character to separate the yellows and the purples.

It would seem from the above that it is entirely possible to tell all yellow raspberry plants from either the red or the purple sorts by a study of leaf coloration. Although this point has not been as carefully studied, it would also appear that, during the dormant period, the bark of the younger canes of the yellows is entirely lacking in any tinge of red or purple. Some purple raspberry bushes

can be distinguished from red raspberries by the lesser amount of coloring on the upper surface of the young leaves, but many have practically the same amount as the red raspberry.

INHERITANCE OF SEX IN STRAWBERRIES.

Strawberry blossoms may be divided into two kinds: Perfect blossoms in which both stamens and pistils function normally, and imperfect in which the stamens are either absent or abortive. Unfortunately these two forms are not always sharply differentiated. Occasionally imperfect blossoms appear on perfect plants and varying degrees of perfectness are shown by different varieties and by the same variety under different conditions.

Over ten thousand station seedling strawberries have been separated into these two classes. From these it is seen that when imperfect blossoms are pollinated by perfect blossoms the progeny are perfect and imperfect in the ratio of one to one.

Imperfect (I) x Perfect (P) = 2177 P + 2218 I

When perfect blossoms are emasculated and then pollinated from other perfect varieties, the usual results are as follows:

Perfect x Perfect = 1199 P + 0 I

At least two crosses, however, have failed to follow the usual order. Prolific crossed with St. Joseph gave one imperfect out of 103 plants and crossed with Governor Fort gave three out of 161 plants.

When perfect blossoms are fertilized with their own pollen, in about half the cases the results are all perfect plants but in the remaining cases imperfect plants also appear in proportions ranging from nearly two perfects to one imperfect to as low as seventy perfects to one imperfect. The total of all selfed seedlings is:

Perfect (selfed) = 3449 P + 461 I

Eliminating all cases that have produced imperfects that are at all doubtful or where the number of plants involved is too small to be of value, the following populations remain:

Marshall selfed	705 P	10 I
Prolific (Sample x Marshall) selfed	1443 P	391 I
Quality (Hunn x Atlantic) "	72 P	43 I

A possible explanation of these results lies along the following lines:

Pollen = ♂ ♀	}	Perfect plants
Ovules = ♂ ♂		
Ovules = ♀ ♀	}	Imperfect plants
P × P = ♂ ♂ × ♂ ♀ = 2 ♂ ♂ + 2 ♂ ♀		

Since we have no pure males in strawberries it would be necessary to assume that ♂ ♂ does not produce a zygote, then:

P × P = 2 ♂ ♀ = 2 Perfects
 I × P = ♀ ♀ × ♂ ♀ = 2 ♂ ♀ + 2 ♀ ♀
 = 2 perfects and 2 imperfects.

To explain the abnormal cases it is necessary to assume the following change in the ovules of certain perfect plants:

$$\begin{array}{l} \text{Pollen} = \delta \text{ } \varnothing \\ \text{Ovules} = x \delta \delta + y \delta \varnothing \end{array} \quad \left. \vphantom{\begin{array}{l} \text{Pollen} = \delta \text{ } \varnothing \\ \text{Ovules} = x \delta \delta + y \delta \varnothing \end{array}} \right\} \text{ Abnormal perfects.}$$

The letters x and y are used because the tendency to abnormality seems to be present in varying degrees.

$$\begin{aligned} \text{P. selfed} &= (x \delta \delta + y \delta \varnothing) \times \delta \varnothing \\ &= (2x + y) \delta \delta + (2x + 2y) \delta \varnothing + y \varnothing \varnothing \\ &= 2(x + y) \text{ perfects} + y \text{ imperfects.} \end{aligned}$$

This would give a higher proportion of perfects than imperfects, an expectation which so far has been realized in all cases. It is interesting to note that the only cases where perfects pollinated by other perfects have given imperfects, have occurred when Prolific (one of the varieties producing imperfects as well as perfects when selfed) was used as a female.

FRAGARIA VIRGINIANA IN THE EVOLUTION OF THE GARDEN STRAWBERRY OF NORTH AMERICA.

By S. W. FLETCHER, *Fishersville, Va.*

In 1894 Dr. L. H. Bailey presented evidence which seemed to indicate that the garden strawberry of North America is a pure form of *Fragaria chiloensis* and is not of the blood of *F. virginiana*, even in part, as had been supposed hitherto. This conclusion found wide acceptance; in recent years *F. virginiana* has been considered a rather negligible factor in the evolution of the North American strawberry. A recent bulletin states, "This species has given but few varieties, and they have soon dropped from cultivation." From the evidence that I have gathered quite opposite conclusions may be drawn—that varieties of the Virginian species have been an important factor in the rise of commercial strawberry growing in North America; and that the garden strawberry of today is of the lineage of *F. virginiana* fully as much as of *F. chiloensis*.

RECORD OF PURE F. VIRGINIANA UNDER CULTIVATION IN NORTH AMERICA.

The Virginia or Scarlet strawberry was the only kind known in early colonial days. The Hauthois, Alpine, Wood and Chilean were not introduced until about 1750; and the Pine, from which most of the European varieties of today have descended, was introduced about 1790. With the exception of the Wood, none of these were grown here, save in the gardens of a few amateurs who could afford to pet them. The Red Wood was valued by market gardeners near Boston between 1820 and 1850.

Beginnings of Commercial Culture: Commercial strawberry culture began in North America soon after 1800, mainly in the vicinity of the four largest towns of that period, Boston, New York, Philadelphia and Baltimore. About that time several nurseries began to disseminate improved varieties of the Scarlet, notably Early Hudson, Hudson's Bay, Methven Scarlet, and Large Early Scarlet. The latter variety and Red Wood dominated the Boston market until the introduction of the Hovey, in 1838. Between 1820 and 1840 the New York market was supplied chiefly with Crimson Cone or Scarlet Runner, a variety of the Scarlet, raised mainly near Hackensack, New Jersey. Anne Arundel county, Maryland, began to grow strawberries for Baltimore and Philadelphia about 1815; the varieties were Hart, Large Early Scarlet and Stewart, all varieties of the Scarlet.

Following the production of Keen's Seedling, in 1819, a large number of varieties of the Pine, mostly descendants of this variety, were introduced here. None achieved prominence save the Mulberry, which was largely grown near Boston about 1835. At the close of this period, with the introduction of the Hovey in 1838, such small beginnings in commercial strawberry culture as had been made were almost wholly with varieties of *F. virginiana*.

Persistence of Varieties of the Scarlet: The Hovey proved decidedly disappointing as a commercial sort, although valued highly for home use. It required high culture, was not hardy, did not make enough plants and, being a pistillate, was very uncertain in pollination. The Hovey did not displace Large Early Scarlet, Hudson's Bay, Early Hudson, Crimson Cone and other varieties of the Scarlet in commercial culture. After 1848 it was rarely quoted in any market except Boston.

During the sixteen years between the introduction of the Hovey and the introduction of the Wilson, there was a considerable extension of the commercial strawberry industry, especially in the territory tributary to Cincinnati, New York and Baltimore. Between 1846 and 1849 Cincinnati was the premier strawberry market of the world. This was partly because the growers there, under the vigorous leadership of Nicholas Longworth, began to mix staminate and pistillate varieties several years before the growers elsewhere could be convinced that this was necessary. According to Charles Gist, 6,500 bushels were marketed in Cincinnati in 1847, netting the growers about six cents per quart. In 1850 there were 200 acres of strawberries in Anne Arundel county, Maryland. The total quantity of cultivated strawberries marketed in 1854, when the Wilson was introduced, did not exceed 40,000 bushels; the total area under cultivation was less than 1400 acres. Excluding the wild berries, which were brought to market in large quantities, it is probable that over ninety-five per cent of the strawberries marketed before 1858, when the Wilson rushed to the front, were pure varieties of *F. virginiana*.

The introduction of the Wilson marked the beginning of modern commercial strawberry culture. The rapidity with which the Wil-

son supplanted other sorts was remarkable, especially since the originator made no effort to exploit it, as had the originator of the Hovey. In 1858, four years after it was introduced, the Wilson vied with Large Early Scarlet and Crimson Cone for first choice in a vote for "the best market variety" taken at a meeting of the Fruit Growers' Association of Western New York. In the same year the American Pomological Society added it to the list of varieties recommended for general cultivation. By 1861 it had largely superseded all other sorts for commercial planting except the Large Early Scarlet. This notable variety retained prominence in western New York until 1864, and was a leading commercial variety at Dighton, Massachusetts until 1865, under the name of "Old Virginia." It passed out of cultivation in North America about 1875, having been the dominant variety for seventy-five years. It is still grown commercially in England and Scotland for making jam.

Since the passing of Large Early Scarlet no varieties known to be pure *F. virginiana* have been grown largely except Cutter's Seedling and Crystal City. The former, introduced in 1859, was grown considerably in New England from 1862 to 1875. William H. Hill assures us that it was pure *F. virginiana*. Crystal City, or Acme, introduced in 1876, was a popular extra early sort, especially for home use, until about 1892. This variety was very similar to Large Early Scarlet.

Several sorts introduced more recently have been supposed to be *F. virginiana*. Among these are August Luther, Michel and Wonder (of Shank). The surmise as to their botany is not capable of proof, but they bear so much resemblance to the Scarlet that it seems probable they are of the blood of that species in some degree. In 1908 a variety known as Earliest was listed as "an improved variety of the Iowa wild strawberry." The prairie form of *F. virginiana* has been much more productive of improved sorts than the eastern form; it is larger, more variable, and responds more quickly to cultivation.

This record of *F. virginiana* under cultivation in North America should be sufficient to clear the species of the charge that it has been but a negligible factor. Whether it enters into the lineage of modern varieties or not, it has contributed largely to the upbuilding of the strawberry industry. For over a century varieties of the Scarlet held almost undisputed control of the strawberry market of North America, limited though it was.

HISTORICAL EVIDENCE ON THE ORIGIN OF THE GARDEN STRAWBERRY.

Turning now to the more speculative phase of the subject—the botanical origin of the varieties of today—it must be keenly regretted that the parentage of the four varieties from which most modern sorts have sprung is so obscure. These stem varieties are the Hovey, Wilson, Sharpless and Crescent. I have been able to obtain records of 1853 varieties which have originated in North America. Of these the parents of only 348 are known definitely.

Sixty-three are descendents of Crescent, sixty-nine of Sharpless, forty-eight of Wilson, and fifty-one of Hovey. Approximately two-thirds of the varieties of known parentage have come from the great four. It is a misfortune that the parents of none of the four are known with certainty, hence the subject must always be one for speculation rather than for conclusive proof.

Origin of the Hovey: When C. M. Hovey produced his famous seedling he made the following six crosses by hand:

1. Methven Scarlet x Keen's Seedling.
2. Methven Scarlet x Melon.
3. Mulberry x Keen's Seedling.
4. Melon x Keen's Seedling.
5. Southborough x Prolific Hautbois.
6. Grove End Scarlet x Keen's Seedling.

All were varieties of European origin: Methven Scarlet, Southborough and Grove End Scarlet, were varieties of *F. virginiana*, while Keen's Seedling, Mulberry and Melon were Pines. Like many another plant breeder since, Hovey was so unfortunate as to lose his labels, so that he never knew positively which cross produced the Hovey. The loss of labels was a far greater misfortune than he could have imagined at that time. In 1840 he asserted,* "We can, however, state that the variety originated from one of the first four crosses and in all probability from No. 1 or No. 4; and we have always thought from the latter." Both of the parents of Cross No. 4 were Pines. It is this statement upon which the conclusion that the Hovey was a Pine has been largely based. It seems to have been overlooked that five years later, perhaps after more careful consideration, Hovey stated:† "Our seedling we have supposed was from Methven Scarlet impregnated with Keen's Seedling." We are justified, therefore, in concluding that it is at least equally probable that the Hovey originated from Cross No. 1, in which case one parent was a variety of *F. virginiana*, as from Cross No. 4, in which both parents were Pines.

Most of the early North American horticulturists believed that the Hovey and subsequent varieties were of mixed blood. In the first edition of his *Small Fruit Culturist*, published in 1867, A. S. Fuller gives a list of "Varieties of *F. grandiflora* and *F. virginiana*." He says, "Some show the characteristics of one species, some of the other; while with a few it would be difficult to tell to which they are related and it is very probable that they are a mixture of both." In 1887 Fuller stated, "There was no real, substantial improvement in strawberry culture in this country until we began to employ the wild varieties as a foundation." In 1879 J. L. Budd said, "In leaf, growth of root and vigor, the Hovey was about a full blooded native, but its fruit was transformed in size and sweetness by pollinizing with the South American species, *F. grandiflora*, a species perfectly worthless in its pure form for

* Mag. Hort., 1840, p. 293.

† Mag. Hort., 1845, p. 292.

culture in this country on account of its delicate habit. Following the Hovey came in succession the treasures which are now found in our gardens. In every case the truly valuable varieties are those with the leaf, low crowns, and deep-extending, wiry roots of our native species, modified in fruit by the South American species." This view was held by Charles Downing, E. P. Roe, W. H. Hill, R. G. Pardee, and other early authorities on the strawberry.

Evidently Charles Darwin was of the same opinion. He said, "As the American strawberries cross so freely and spontaneously we can hardly doubt that they will ultimately become inextricably confused. We find, indeed, that horticulturists at present disagree under which class to rank some few of these varieties; and a writer in the *Bon Jardinier* of 1840 remarks that formerly it was quite possible to class all of them under some one species, but that now this is quite impossible with the American forms, the new English varieties having completely filled up the gaps between them."

What Was the Pine Strawberry? If, however, we assume that both parents of the Hovey were Pines the problem is even farther from solution. What was the Pine strawberry? Recent investigators have dissented from the conclusion of Bailey that it was pure *F. chiloensis*. In 1914 C. W. Richardson, an English plant breeder, expressed this opinion:* "Something of the origin of the modern garden strawberry is known, but its whole history is not. It springs from an old form of garden strawberry, the result of crosses between *vesca*, Alpine, and Hautbois. This older form was again crossed with *F. virginiana* introduced in 1629, and with *F. chiloensis*, introduced in Marseilles in 1712 and to England in 1727 by Philip Miller. These crosses were again crossed with *F. ananassa* (*F. grandiflora*), introduced from Holland during the eighteenth century. The origin of this plant is unknown. It was said to have been brought from Surinam, where today there are said to be no strawberries. It is also said to have been a variety of the Virginian brought from Carolina. It may be a *chinensis* cross, as Holland received many plants from China during the eighteenth century. Whatever its origin, all our best garden varieties of today are descended from *F. ananassa* crosses. I have selfed eight varieties of garden fruit, producing over 1000 plants. Not one resembles a *vesca* or an Alpine, but many show distinct traces of *chiloensis*, more of *virginiana* and not a few of *chinensis*."

E. A. Bunyard, another English student of *Fragaria*, believes that the original Pine was a seedling of *F. chiloensis* but adds:* "To Thomas Andrew Knight and Michael Keen must be given the honor of laying the foundation of the strawberry of the present day. The two most important species had existed for some time in English gardens and it was to the crossing of early descendants of *F. virginiana* and *F. chiloensis* that this success was due." And again, "The introduction of the Chilean strawberry, *F. chiloensis*,

* Jour. Genetics, 3 (1914) p. 173.

Prince, and Ross Phoenix. Both of the latter were Pines, Black Prince being a seedling of Keen's Imperial and a direct descendent of the original Pineapple strawberry, while Ross Phoenix was a seedling of Keen's Seedling. These seeds were the result of natural pollination, not of hand crossing. James Wilson was always confident that his famous seedling was Hovey x Black Prince, according to a statement made after his death by his son, John Wilson, and this opinion was shared by his contemporaries. "The Wilson is probably a seedling of the Hovey," asserted A. S. Fuller, in 1867. This surmise, however, was based simply upon the appearance and behavior of the Wilson and its seedlings, not upon authentic records. It must be admitted that the Wilson and its seedlings resemble *F. virginiana* more closely than the Hovey.

If we assume that the Hovey was one of the parents of the Wilson, then the forty-eight varieties that are known to have descended from the Wilson are of the same lineage. Of these the following are in cultivation today: Bisel, Charles Newman, Cobden, Early Harvest, Early Hathaway, Excelsior (of Hubach), Hubach and Hathaway, Jim Dumas, Maud Muller, Ozark, and Satisfaction.

Descendants of the Sharpless: The Sharpless was originated in 1872 by J. K. Sharpless, Catawissa, Pennsylvania, from hand sown mixed seed of Jucunda, Charles Downing, Wilson and Col. Cheney. The originator always believed that it was a seedling of the Charles Downing, but this must remain a matter for speculation. The Charles Downing was a seedling of Downer's Prolific, which was bred from the native strawberry of Iowa. If we assume that the surmise of Mr. Sharpless was well founded, then the sixty-nine varieties known to have descended from his seedling are of *F. virginiana* blood, in part. Of these, the following are grown today: Barton, Berlin (of Schild), Buster, Carrie, Carrie Silvers, Columbia (of Wild), Elma, Enhance, Fisher, Glastonbury, Haverland, Helen Gould, Heritage, Howard (of Black), Hubach, Hathaway, Jessie, Jim Dumas, Joe, July, Lady Jane, Lindenwald, Luxury, Manokin, Marconi, Midnight, Mrs. Fisher, Nettie, Nicaragua, Ninety-six, Oom Paul, Oregon, Paul Jones, Porto Rico, Quality (of the N. Y. Exp. Sta.), Rose Ettersburg, St. Louis (of Bauer), Sparta, Stella, Tennessee (of Hodges), Velvet, Virginia, Warren (of Thompson), Williams (of Ontario).

Descendants of the Crescent: The Crescent was a chance seedling found by William Parmalee, of New Haven, Connecticut, in 1870. It has been supposed by many to be a pure seedling of *F. virginiana*, and it certainly shows many of the characters of that species, both in plant and fruit; but this is mere conjecture. Sixty-three varieties have descended from it, a number of which inherit Sharpless blood also through the Haverland, a Sharpless-Crescent cross. Forty-six of these are in cultivation now, as follows: Berlin (of Schild), Bismark, Bountiful, Bradley, Carrie, Carrie Silvers, Clyde, Columbia (of Wild),

Cyclone, Daisy (of Zane), De Wet, Enormous, Glastonbury, Ham, Haverland, Hawaii, Johnson, July, Kevitt, Lady Jane, Louis Hubach, Luxury, Manokin, Mele, Midnight, Nicaragua, Olive, Parker Earle, Paul Jones, Porto Rico, Red Prolific, Ridgeway, Robbie, Robinson, Roosevelt (of Cathcoit), St. Louis (of Bauer), Shuster, Stone, Tennessee (of Hodges), Van Deman, Warren (of Thompson), Williams (of Ontario), and Yalu.

Descendents of Downer's Prolific: Thus a majority of the varieties of known parentage, those out of the Hovey, Wilson, Sharpless and Crescent, are supposed to contain the blood of *F. virginiana* in part. There are a number of varieties, however, in which the surmise becomes a certainty. In 1854, J. S. Downer, of Fairview, Kentucky, produced Downer's Prolific. In 1876, James Smith, of Des Moines, Iowa, stated at a meeting of the Iowa State Horticultural Society, "Downer produced his Downer's Prolific from seed of the native Iowa strawberry," which is a form of *F. virginiana*. Andrew S. Fuller called the Charles Downing, which was a seedling of Downer's Prolific, "a large representative of the western *F. virginiana*, var. *Illinoensis*." In the American Horticultural Manual J. L. Budd asserts, "We know that the Charles Downing sprang from the western wild species (*Fragaria Illinoensis*) pollinated by a Chilean variety; and we also know that in habit of growth and runners and in choice aromatic flavor it follows the native, while the Chilean pollen has given size of fruit and decidedly modified the foliage. Our native species has also transmitted the required hardiness." This view was commonly accepted by the horticulturists of that period. The rampant growth of runners and the deeply imbedded seeds of the Charles Downing were marked indications of *F. virginiana* blood. It is believed by some that Downer's Prolific is still grown to a limited extent in the northern Mississippi valley, especially in Minnesota, under the name of Countess.

The Charles Downing became a great commercial variety. Between 1875 and 1890 it was a close competitor of the Wilson. Ten of its descendents are in cultivation today, most of them coming through Windsor. These are: Enhance, Ham, Hazel, Marconi, Mary (of Alley), Millionaire, Nina, Reba, Reliance and Robinson. We now have but two varieties; the Elma and the Robbie, that have descended from the Kentucky, another notable seedling of Downer's Prolific.

Other Varieties With Scarlet Blood: Several other varieties of some prominence have been, beyond question, of *F. virginiana* blood in part. One was the Bidwell, which was widely grown for home use between 1880 and 1895. This variety was produced by Benjamin Hathaway, of Little Prairie Ronde, Michigan, by crossing, to quote from him, "what I call the Pistillate Scarlet, that came out through three or four generations from the old Virginia Scarlet," with Wilson, Sharpless and Glen-

dale as pollinizers. The Michigan, another noted variety produced by Hathaway, was this same Pistillate Scarlet crossed with Burr's Seedling. It was widely planted between 1865 and 1875. Hathaway's statement of the origin of these two varieties was verified by T. T. Lyon. No descendants of Bidwell and Michigan are in cultivation today, although the Heath, which was Crescent x Bidwell, was grown about 1900.

F. virginiana has been used in a number of crosses made in recent years. The Goldsborough, originated by A. T. Goldsborough, of Washington, D. C., and introduced in 1903, is British Queen x *F. virginiana*. The originator says, "Its red pulp leaves a red juice in a saucer, like the wild parent of the fields, a quality almost bred out by the introduction of the South American sorts, which are white fleshed." The Dewdrop, originated by H. F. Dew, of Albion, Michigan, and introduced in 1906 as an "everbearer," is said to be Dew x Jucunda x "a wild prairie strawberry."

BOTANICAL EVIDENCE.

This completes the evidence of history in support of the contention that *F. virginiana* has entered largely into the lineage of the modern strawberry. There remains the evidence of botany. At first thought it might seem that it should be comparatively easy to determine from what species the garden strawberry has sprung by making comparative studies in anatomy, yet this has not given conclusive results. The genus *Fragaria* is a most flexible and unstable group of plants. Botanists rarely agree upon the limits of a species. Some would make several species out of the group of plants known loosely as *F. virginiana*.

One line of evidence upon which Dr. Bailey based his conclusion that the garden strawberry is a form of *F. chiloensis*, was the behavior of some plants of that species which he transplanted from Oregon to New York. Within three years they changed from squat, blue-leaved, short-trussed, densely hairy plants to "tall growing, green leaved, high trussed and thinly hairy" plants, closely resembling many modern varieties. This, however, is not necessarily proof that the modern strawberry descended from *F. chiloensis*; it may be merely proof of the remarkable plasticity of the species. Equally marked variations from the type may be found in different locations on the Pacific Coast. The Alaskan beach form, which C. C. Georgeson has used in breeding varieties adapted for that region, has procumbant fruit stalks, and peduncles that are "so long that the fruit usually ripens out of sight, under the vegetation at the base of the plant." The Virginian species is equally variable.

Over a century ago, Thomas Andrew Knight, the father of strawberry breeding, made many crosses between the Scarlet, the Chilean and the Pine. According to Burbidge, he reached this conclusion: "That all the large Scarlet or American strawberries (of which *F. virginiana*, *F. chiloensis*, and *F. grandiflora* are the supposed species or types), were referable to the same species, since not only did they inter-breed indiscriminately in his garden, but he

demonstrated also that similar varieties may be obtained from seeds of any of these so-called types." There is much modern evidence in support of this conclusion.

Reversion of Seedlings: If, however, we accept *F. virginiana* and *F. chiloensis* as distinct species, with points of differentiation as set forth by the systematic botanist, still there are good reasons for believing that both have entered into the lineage of the modern strawberry. Perhaps the most weighty of these is the character of the seedlings. A large proportion of the seedlings resulting from a strawberry cross tend to revert to a more primitive type; usually over ninety per cent of them are decidedly inferior to either parent. In 1886 E. Lewis Sturtevant, reported his observations on this point to the Massachusetts Horticultural Society: "The modern varieties under American culture seem to belong mostly to the species represented in nature by *F. virginiana*, although there are supposed hybridizations with *F. chiloensis*, and, in the high flavored class, with *F. clatior*. Certain it is that in growing seedlings from our improved varieties reversions often occur to varieties referable to the Hautbois and Chilean sorts, from which fact hybridization can be inferred. I have noticed as of common occurrence that seedlings from high flavored varieties are very likely to furnish some plants of the Hautbois class and scarcely if at all distinguishable from named varieties of the Hautbois with which there has been opportunity for close comparison. From large berries of diminished flavor and which occasionally throw hollow berries the reversion occasionally produces plants unmistakably of the Chilean type. In other cases we have noticed reversions to forms of *F. vesca*. These circumstances all lead towards establishing the mingled parentage of our varieties under cultivation." This conclusion agrees with that of Richardson, previously quoted, that the modern strawberry is a composite of several species, including the Hautbois, and *vesca*, as well as the Virginian and Chilean.

Position of Seeds: While the anatomical characters of modern varieties furnish no conclusive clue to their botanical origin, there are several points worth noting. The position of the seeds is a character of segregation between the Chilean and the Virginian species. In the former they are commonly exserted or but slightly imbedded; in the latter they are sunk into deep, angular pits. Most of the early North American varieties had sunken seeds. According to Hooper's Western Fruit Book, the seeds of the Hovey were "imbedded in a small cavity." Modern varieties show both contrasting characters, but those with exserted seeds are more numerous now as the berries are less likely to be bruised. But little weight can be attached to this character, however, since some forms of *F. chiloensis* have sunken seeds. Albert F. Etter, a strawberry breeder of Briceland, California, says that the local form of *F. chiloensis* has "seeds deep set, while the seeds of the same species from Peru are not so deep set."

Necked Berries: A much more plausible mark of *F. virginiana* is the long neck which characterized so many of the varieties fol-

lowing the Hovey. The berries of *F. chiloensis* rarely have a pronounced neck; but this feature is quite common in the Virginian and in *F. vesca*. The Banana strawberry, introduced about 1870, was the most conspicuous example of a necked variety; its neck was half as long as the entire berry. This variety was a descendent of Hovey, being a seedling of Agriculturist, which came from Green Prolific, which was a seedling of the Hovey. Long necks have gone out of fashion now, since such berries do not carry to market well, but berries with short necks are preferred to those without any neck, as they can be capped more readily.

Exuberent Runners: The abundance of runners of many modern varieties is a convincing indication of *F. virginiana* blood. Some forms of *F. chiloensis*, as the Alaska beach strawberry, have numerous runners, but the species as a whole is characterized by a very moderate runner production as compared with *F. virginiana*. The wild Scarlet makes runners in the greatest profusion. This habit has always been one of the greatest defects of the Scarlet under cultivation; it makes so many plants that the bed is overcrowded and consequently the fruit is very small.

The Hovey was a moderate plant maker, but a large proportion of the varieties following it were exceedingly prolific of plants. The Colfax, introduced in 1867, was said to "kill weeds and everything else and completely occupy the ground." In 1860 J. A. Warder recommended the Necked Pine as "death on blue grass; it will jump over the fence and escape everything that trespasses. Plant it thirty feet apart and let it run." The Crescent was so prolific of plants that many growers set it ten feet apart each way, and still got a good stand in normal seasons. Consider also the remarkable plant-making ability of Cumberland Triumph and many of its progeny, all descendants of the Hovey; and the rampant runners of the Charles Downing. It is exceedingly difficult to associate this free running habit with a pure strain of *F. chiloensis*. Few of the varieties of more recent introduction produce runners as freely as this, because it is no longer desired. We have come to the point where some degree of runner restriction is considered essential to the production of good fruit; naturally this ideal is reflected in the selection of seedlings. The exuberance of runners that characterized the varieties following the Hovey may be considered a strong indication of *F. virginiana*. English varieties, which probably have less Scarlet blood than American sorts, are noted as moderate plant makers.

Hardiness: The superior hardiness of North American varieties as compared with English sorts, is another case in point. Most plant breeders agree that the attribute of hardiness cannot be acquired in a few years, by selection, unless the plant under consideration happens to be a heterozygote. As a general proposition, hardiness is the result of some thousands of years of natural selection. Hence, if we wish to secure hardier varieties of a tender plant in our own generation the most practicable course is to infuse the blood of a hardier species.

There are some places where *F. chilensis* is quite hardy, but for the most part it is a tender species. Its habitat is the more tempered regions of North and South America. The South American form, from which the Pine is supposed to have been derived, is especially tender. *F. virginiana*, on the other hand, is decidedly hardy. It grows close up to the snow line. It withstands temperatures of forty degrees below zero and survives even the extreme conditions on our northwestern prairies. It has been used recently by Hansen to breed greater hardiness into some of the common varieties, with marked results, so far as this one attribute is concerned.

Modern English varieties are believed by some to be pure *F. chilensis*; and by others to be a composite of several species, with a comparatively small infusion of *F. virginiana*. They are distinctly inferior to American varieties in hardiness. Since 1819, when Michael Keen produced his noted seedling, the progenitor of modern English varieties, North American horticulturists have repeatedly attempted to grow the European sorts. Almost invariably they fail here; they lack vigor and hardiness. Jucunda and Triomphe are notable exceptions. The race of strawberries that has developed in North America since the introduction of the Hovey, however, is sufficiently hardy to succeed under commercial culture in all parts of the continent except where climatic conditions are exceptionally trying, as in the Dakotas, Minnesota, Manitoba and Saschatchewan. It is difficult to conceive that a pure form of *F. chilensis* could have acquired this remarkable degree of hardiness, so foreign to its nature in the wild, within so short a period. It is much more likely that the greater hardiness of North American varieties as compared with English sorts, is due to a larger admixture of the more hardy species.

There are other characters of modern varieties, both in plant and fruit, that indicate a mixed origin. Some varieties show the division of the crown, the deep feeding, wiry roots and red flesh of *F. virginiana*; others show the undivided crowns, shallow feeding, fleshy roots, and white flesh of *F. chilensis*. These points, however, are of less significance than those that have been mentioned.

Behavior of Pure F. Chilensis Under Cultivation: A strong argument for the hybrid origin of the garden strawberry is found in the record of pure *F. chilensis* under cultivation. Although this species has been grown in Europe for two centuries, it has produced but few varieties and none of these has been found worthy of general cultivation. It was offered for sale in one of the first North American trade catalogs, which was sent out by Prince's Linnaean Gardens, in 1771. The White Chilean was grown sparingly for preserves until about 1860, especially in California, but never was popular outside of the gardens of a few amateurs. It has shown but little tendency to vary under cultivation; the few varieties differ mainly in the color of the fruit. *F. chilensis* is indigenous to our entire Pacific seaboard; yet I have not been able to discover a single variety that has sprung from it during the hundred years that have

elapsed since there has been any considerable interest in strawberry culture on this continent, except, possibly, the Honey, which was introduced by S. L. Watkins, of Grizzly Flats, California, in 1892.

It might be argued with justice that the South American form of *F. chiloensis*, from which the Pine is supposed to have sprung, may have possessed a tendency to vary into improved forms that is lacking in the North American representatives of the species. This phenomenon is seen in the native plum, *Prunus americana*. Practically all of the valuable varieties of this species have come from the Mississippi valley; the eastern form shows little profitable variation. Yet it would seem reasonable to expect that if North American varieties of the strawberry are of *F. chiloensis* blood, and nothing else, the species should at least give us an occasional improved variety in these latter days. *F. virginiana* was the mainstay of strawberry culture in North America for over a century. Would it not be strange indeed if it were suddenly and completely dispossessed by a species that is known to have produced no valuable varieties in a pure form, either here or in Europe, during the 200 years that it has been in cultivation?

The evidence here presented, shows that varieties of *F. virginiana* dominated the strawberry culture of North America until fifty years ago; that one of the parents of the Hovey, the chief progenitor of modern varieties, was a Pine, which several recent investigators agree was a hybrid between *F. virginiana* and *F. chiloensis*, and possibly several other species; that the probabilities are at least equal that the other parent of the Hovey was a variety of *F. virginiana*; that a number of varieties in cultivation today are descendants of Downer's Prolific, which is known to have contained *F. virginiana* blood; that varieties since the Hovey show strong indications of *F. virginiana* in the reversion of seedlings, the position of seeds, the prominent neck, the exuberant production of runners, and in superior hardiness; that pure *F. chiloensis* has shown but little tendency to vary under cultivation and has given no valuable varieties. This evidence seems to justify the conclusion that the garden strawberry of North America is of mixed origin, with *F. virginiana* and *F. chiloensis* predominating.

A GENETIC ANALYSIS OF HORTICULTURAL VARIETIES PROPAGATED BY VEGETATIVE MEANS.

By D. F. JONES, *Bussey Institute, Boston, Massachusetts.*

Many varieties of plants normally reproducing by seed in the wild, are propagated in commercial practice by vegetative means. This is done in order to perpetuate desirable creations and to secure uniformity of product. Particularly is this the case in fruits, ornamental shrubs, and many flowers where varieties are continued indefinitely by budding, grafting, cutting, etc.

In attempting to improve any plant by breeding it is essential to determine, if possible, the underlying reasons why the already

existing varieties are worthy of cultivation. Before trying to improve plants propagated by vegetative means it is necessary to determine whether this practice of vegetative propagation has influenced indirectly the germinal constitution of varieties propagated in that way.

Since they normally reproduce by seed, it is safe to assume that the same principles which have been determined for annual seed-bearing plants apply equally well to the perennial horticultural crops. Existing varieties of fruits are worthy of cultivation because they represent rare and fortunate combinations of many desirable genetic factors. In other words, they represent extreme plus variates from a frequency distribution in which the variation is caused by a large number of constantly segregating and recombining characters. In addition to this it seems probable that these varieties owe a part of their superiority to heterosis or hybrid vigor. This phenomenon must be taken into consideration in fruit breeding work.

That the vigor due to heterozygosis is a factor in the production of desirable horticultural varieties seems evident for the following reasons:

1. It is a matter of common knowledge that seedlings of horticultural plants in most cases are not true to the type of the parent. This indicates that the parents are in a hybrid condition for a large number of factors. Heterosis has been shown to be directly correlated with the degree of heterozygosity.

2. Inbreeding experiments with fruits have shown that almost without exception there is a noticeable decrease in vegetative vigor attending systematic inbreeding. This is directly comparable to the same condition which is found in a naturally cross-bred annual plant, such as corn. The reduction in vegetative vigor is rapid at first, then gradually slows down and finally ceases.

3. When these inbred strains of corn are crossed there is an immediate return of vigor in the F_1 generation often surpassing the original parents. Since by vegetative propagation any generation can be perpetuated indefinitely there is every reason to believe that natural crosses among existing varieties of fruits and among wild plants have resulted in an increase of vigor because of their hybrid condition, and these crosses have been selected for cultivation.

4. In some cases crosses between existing varieties, particularly the apple, result in progeny less vigorous than either parent. In plants widely crossed further crossing may theoretically result in individuals less heterozygous than either parent, although segregation of factors seems the more logical explanation for most of these cases of poor offspring.

Over one hundred first-generation crosses between commercial non-inbred varieties of corn have shown a large number which surpassed the better parent in yield. This increase over the better parent has rarely been over ten per cent. Crosses between inbred strains have given fifty per cent increase in yield over the better parent before inbreeding. Yields of 140 bushels per acre have been obtained from these crosses between inbred strains (East and Hayes,

1912). If there were any practicable way of propagating corn by vegetative means on a commercial scale, as for example there is in sugar cane, then these first generation hybrids would make desirable varieties of corn to be perpetuated indefinitely as are the varieties of fruit.

If heterosis plays a part in creating valuable horticultural varieties the extent to which it is a factor should be determined and reckoned with in breeding practice. If it is of considerable significance, then the somatic expression of a variety may give little or no indication as to its breeding value. If, for example, the good qualities of the Northern Spy apple or the Senator Dunlap strawberry are due in part to heterosis, then these varieties may be poor parents to use in transmitting these characters to new individuals. In the crosses between the non-inbred varieties of corn previously referred to, high-yielding first-generation hybrids have been secured from inferior parental varieties, while in some cases high-yielding parents have given crosses which were poorer than either parent.

A quotation from a recent Geneva Experiment Station bulletin (Hedrick and Anthony, 1915) is in direct confirmation of this statement. "One of the surprises in the study of varieties of grapes was the failure of many of our commercial sorts to transmit desirable qualities to their progeny. Seedlings of Concord, Niagara, Worden, Delaware and Catawba grapes, have so far proved only disappointments. The best results have been secured from such little-grown varieties as the Ross, Collier, Mills, Jefferson, Diamond and Winchell."

Any plant in a hybrid condition is unsatisfactory material to use in attempting to systematically recombine desirable characters. When using heterozygous parents the chance of securing the union of the gametes carrying the desired factors is made possible, where there is independent segregation, by making a sufficiently large number of crosses. But assuming that the varieties to be used as parents are each heterozygous for eight different factors which are wanted in the recombination, $65,536 [(2^n)^2, \text{ where } N = 8]$ crosses will have to be made in order to run an even chance of securing the plant recombining all the desired characters. This is estimating that on the average one plant can be grown to maturity from each cross. If, however, one parent is pure, and the other heterozygous for eight factors, only 256 crosses will have to be made to have an equal chance, as before, of getting the desired combination. When both parents are in a homozygous condition only one cross is needed.

The characters generally sought by fruit breeders at the present time are quality, texture, hardness, etc. Such general characters are possibly affected by factors carried in all the chromosomes, as suggested by East (1915). Taking the chromosome number 8 of the rose to be the same for the rosaceous fruits, it is not unlikely that varieties of fruit are in a heterozygous condition for 8 sets of independently segregating characters. (In this connection it is to be

hoped that the chromosome number for all the cultivated fruits will be definitely determined.)

The chief difficulty in reducing perennial, slow-maturing plants to a homozygous condition is the length of time involved. It takes from six to eight generations to reduce a mixed population to nearly complete homozygosity. The time needed will vary from ten to fifteen years in the case of the strawberry to fifty to one hundred years in a slow-fruited tree like the apple. By growing a large number of individuals and following their behavior in pedigreed lines some practically homozygous strains can doubtless be secured in a fewer number of generations.

The advantages to be gained by inbreeding are as follows:

1. It will give material of known genetic constitution which can be used to study the mode of inheritance of the characters desired in horticultural plants. Crosses between individuals already in a complex hybrid condition are difficult to analyze from a genetic standpoint.

2. With this information, recombinations by crossing these pure breeding lines can be secured with some degree of certainty.

3. Crosses between these homozygous individuals should give the greatest possible stimulus due to heterozygosis. Horticultural practice is well adapted to make use of this means of improvement if it has significant value.

In this connection a distinction is apparent between annual and perennial plants. In annuals there is a direct correlation between vegetative vigor and productiveness. In the perennial fruits excessive vegetative vigor caused by cultural means is often directly opposed to fruitfulness. It may be that heterosis may have somewhat the same effect.

In general, heterosis increases the rapidity of cell division. It affects the size of organs rather than increases their number. In the fruit crops it may serve to stimulate the development of large fruits rather than increase their number. It may be that here is a partial explanation of the large size and rather small number of fruits of varieties like the Northern Spy apple and the small size and great abundance of fruits of varieties such as Winesap, Missouri Pippin and others. No doubt other factors are also concerned.

In spite of the discouraging amount of time necessary, pure breeding strains of all the distinct horticultural varieties would have so much value as to warrant an attempt in this direction. The hope of securing quick results in fruit breeding, except by accident, must be generally abandoned. If the genetic principles worked out during the past fifteen years are to be of the greatest benefit to practical fruit breeding, it is important to determine just what part heterosis has in the production of horticultural varieties propagated by vegetative means.

In the Geneva Station bulletin previously quoted the statement is made that "3,000 selfed grape seedlings * * * have been so uniformly lacking in vigor as to lead to the belief that only through

cross-breeding can we hope to produce improved varieties." In the opinion of the writer it is only through *inbreeding* followed by crossing that we can hope to obtain the greatest improvement.

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THE ORIGIN OF THE HUBBARDSTON APPLE

By J. K. SHAW, *Agricultural College, Amherst, Massachusetts.*

The Hubbardston is one of the more important of the minor varieties of the Baldwin apple belt. It has not been much planted in New England during recent years but is very frequently found in old orchards and occasionally in recent plantings. It has been reported that its culture in New York is increasing and it is more or less known in Michigan and other parts of the Baldwin territory. In other sections of the country it is rarely grown but it is known by reputation, at least, to all pomologists. The first mention of the Hubbardston known to the writer is by Kenrick in 1832 who describes it and highly commends it for general culture. He gives the erroneous information that "it ripens in February and lasts till April" and states that it originated in Hubbardston, Massachusetts. Dr. Thacher in his *American Orchardist* in 1822 does not mention it nor is it included in a list of varieties, recommended for planting, in the *New England Farmer* in 1827, but is found in a similar list published in 1834. From the date of first publication by Kenrick its mention by New England pomologists is frequent, and includes considerable discussion of its season, the reason for which we can now understand. It is stated by Hovey in 1851 that the Hubbardston was introduced by Capt. Hyde of Newton previous to 1830. This was the Samuel Hyde whose name appears among the members of the Massachusetts Horticultural Society in 1838 and in 1843, but is not present in the list for 1856. This Capt. Hyde ran a nursery in Newton for many years and was succeeded by his son George who was also a member of the Massachusetts Horticultural Society. This nursery attained considerable local fame, continuing within the memory of men now living, and I am told that some of the trees still persist on the old site. Kenrick was also a

resident of Newton and prominent in the Massachusetts Horticultural Society, which may explain why he was first to put the variety on record.

The town of Hubbardston is situated in the north central part of Massachusetts and it has fallen to the lot of the writer in each of the past three years to visit the neighboring town of Princeton for the purpose of judging fruit at a local fair. Each year there has been shown what we know as the Hubbardston under the name of Seek-no-further, while a distinct and unknown variety was shown under the name of Hubbardston. The matter seemed worthy of a little investigation, so a day was spent interviewing the leading men and old inhabitants of Hubbardston. This was enough to prove that this unknown sort is the one known everywhere in that town as the Hubbardston, while the true Hubbardston is little known and not highly esteemed. No one can prove to an inhabitant of the town that it is the genuine Hubbardston.

The local Hubbardston may be described as follows: Size, above medium to large; form, oblong, slightly conic, often approaching roundish, oval or irregular pentagonal in cross section; color, light greenish yellow, mottled, splashed and striped with bright red covering from 30 to 70 per cent of surface; bloom, rather light, waxy; dots not very conspicuous, many, small, roundish, pale gray, often submerged; cavity, medium in depth and breadth, angular; stem rather short and slender; basin medium depth, medium to rather broad, sides steep to abrupt, ribbed and folded; calyx closed; stamens, median to marginal; core axile, medium size, median, turbinate, core-lines meeting or clasping; cells closed, medium size, symmetrical; flesh nearly white, rather coarse, crisp, moderately juicy; flavor pleasant acid; quality good to very good; season, October to January. It is apparently productive and of good shipping quality.

The original tree of this local Hubbardston grew in the pasture on a farm located in that part of the town known locally as Burnshirt Hill, and perished within the memory of men now living. It was brought to the attention of the public by the owner of the farm, one Mr. Browning, and has been considerably top-worked in Hubbardston and adjacent towns, but evidently has never gotten into the hands of nurserymen nor been widely disseminated. Several trees of this variety were found in an old orchard on this farm and strangely enough next to them a tree of the genuine Hubbardston, but known there as Seek-no-further. The real Seek-no-further or Westfield is not known in that vicinity.

The first dissemination of the local Hubbardston must have been previous to 1845, as the writer has talked with men who knew it at that time and whose word may be relied upon. It is impossible to say how long before. The genuine Hubbardston probably came into the hands of Samuel Hyde between 1820 and 1830 and it is possible that he got the scions from the town of Hubbardston. This may have been through the hands of one William Hyde, who came to Hubbardston from Newton in 1795 and lived there many years.

There was a distant relationship between this William Hyde and Samuel Hyde. He settled in the easterly part of the township diagonally opposite the place of origin of the local Hubbardston. The writer was informed by an old inhabitant that his father got scions of the genuine Hubbardston (which he called Seek-no-further) from that part of the town toward Westminster, which is the easterly part of the town.

In conclusion then, it is probable that the variety we know as Hubbardston originated in the easterly part of the town of Hubbardston, was carried through the agency of William Hyde to Newton, propagated and disseminated from the nursery of Samuel Hyde and brought to general public notice by William Kenrick in his *American Orchardist*. It has never been known as Hubbardston in its home town. Probably it got the local name of Seek-no-further through its resemblance to Westfield.

Not long after there appeared in the opposite corner of the town another distinct variety which was called Hubbardston and quite generally top-worked in the surrounding country. This variety has possessed itself of name and fame locally while the other has obtained recognition through the country at large. While the local Hubbardston is apparently an excellent variety there is no reason to expect that it will attain more than local distribution, therefore no wide-spread confusion is likely to result from the clash in nomenclature. This is merely a rather interesting episode in pomological history.

The following extract is from "Transactions of the Massachusetts Horticultural Society," for the year 1875, pp. 61 and 62, by Mr. J. B. Moore, an ex-President of the Society.

"In the summer of the year 1871, I was spending a few days in the town of Hubbardston, Massachusetts, and being interested in fruit, I had a desire to ascertain the history of the Hubbardston Nonsuch apple. For information I was referred to Mr. Bennett, who for many years had been town clerk of that town, as knowing probably more about it than any other person. Mr. Bennett informed me that the original tree was still alive, growing on land owned by Mr. Joseph H. Harris, on that part of his farm called the Gleason farm, and situated about four miles west of the village of Hubbardston. I then went with a friend to the Gleason farm, which has no buildings, they having been burnt sixty-five years ago, and the farm being now occupied as a pasture. Near where the buildings formerly stood is an orchard of about half an acre, composed entirely of trees bearing wild or natural fruit. Near the center of this group of trees stands the original Hubbardston Nonsuch, now an old tree, the trunk of which is about fifteen or sixteen inches in diameter and hollow, the top broken off at about eight feet above the ground. Vigorous branches had started from the sides of the trunk near the place where the top was broken, and had formed a small sized head, which, as I have since been informed, produced that year

two barrels of good apples. I examined the tree carefully to find whether there was any evidence of its having been engrafted, and was satisfied that it had not been. Mr. Bennett, at my request, ascertained that Barzillai Gleason built a house and barn and started this farm about the year 1780, and probably about the same time planted the seed for this old orchard, which would make the trees nearly one hundred years old. These trees are not in rows, but stand at irregular distances, as many old orchards were formerly planted. The orchard, and in fact the whole farm, occupies a westerly slope, about half way from the top of the hills, which are large, to the valleys, and has a soil of gravelly loam, quite rocky, cold, and rather wet, and is what would be called good grazing land.

"This apple was first brought to notice by a Mr. Murdock, of Newton, Mass., who had friends living on the next farm. Returning from a visit to Hubbardston, he carried with him a few of these apples; some of them he gave to Mr. Samuel Hyde, of Newton, who was engaged in the nursery business, and who was so much pleased with the fruit that he procured scions, and propagated and disseminated it. This was about the year 1828 or 1830. Previous to this time a man by the name of Dana Parker, of Hubbardston, had called it the Nonsuch; Mr. Hyde, to distinguish it from other apples of that name, called it the Hubbardston Nonsuch. This Mr. Dana Parker claimed to have originated the variety by engrafting a sour apple tree with scions from a sweet one, and some credulous persons believed it; but there stands the old tree, a living witness to the falsity of any such pretensions."

ITEMS OF BUSINESS AT THE ANNUAL MEETING.

It was felt by many of the members that there should be a committee on horticultural research and experimentation, and after much discussion a motion creating such a committee of five members was passed. This committee consists of L. H. Bailey, chairman; H. J. Webber, W. T. Macoun, W. L. Howard and U. P. Hedrick.

The committee on graduate course was continued, and a new one on undergraduate course was provided for to replace the former committees on pomology, olericulture and floriculture. The score card committee was continued.

The officers and committees as given on page 5 were elected or appointed in the usual way.

An amendment to the constitution was adopted increasing the annual dues from \$1.00 to \$1.50 beginning January 1, 1916.

An application for membership in the Society was received from an official Japanese horticulturist. After thorough discussion it was decided to accept foreign official horticulturists as members upon payment of the annual dues.

An amendment to the constitution was offered changing the name of the Society to "American Society for Horticultural Science." Following the necessary method of procedure, this amendment can not be voted on until the next annual meeting.

RESOLUTIONS.

The committee on resolutions offered the following:

Resolved: That the members of the Society extend a cordial vote of thanks to Prof. Paddock and all the members of the Horticultural Department, and to the Ohio State University, for the many kindnesses and great hospitality shown us; for the use of their most excellent quarters in the horticultural-forestry building, and for the good will which has been so evident on every hand.

Resolved also, That a special vote of thanks be tendered the members of the Columbus Horticultural Society for the splendid dinner and much enjoyed smoker which they provided for the members of our Society.

B. S. BROWN,
J. E. COIT,
J. W. CROW,
Committee.

OBITUARY.

GUSTAVUS BENSON BRACKETT.

Colonel Gustavus Benson Brackett, who for the last eighteen years has been chief pomologist of the United States Department of Agriculture, passed away August 2, 1915, at Washington, D. C., at the advanced age of eighty-eight years.

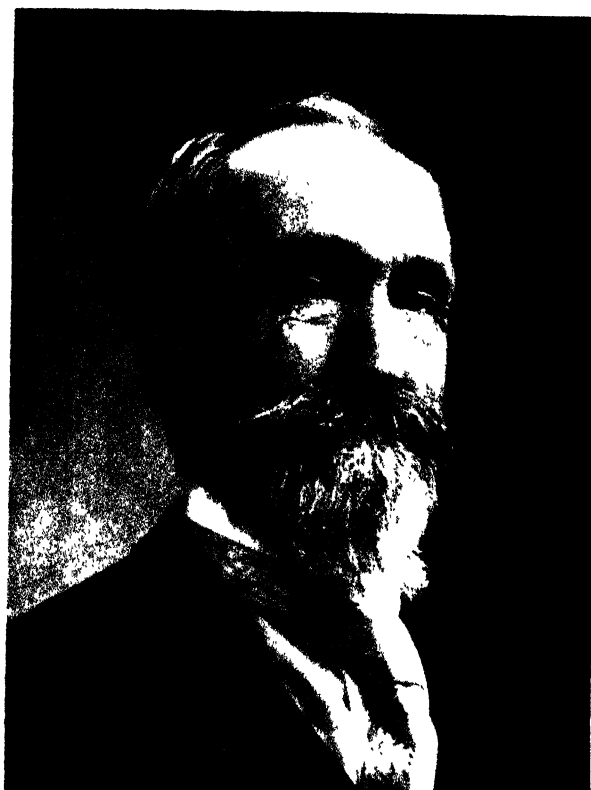
He was born at Unity, Maine, March 24, 1827, receiving his education in the schools of Lynn, Massachusetts, and Cincinnati, Ohio. During the Civil War he served three years, holding positions as captain of engineers on General Grant's staff. After the war he held position as lieutenant-colonel in the Iowa militia.

He has to his credit more than seventy years of active and energetic work for the American fruit industry. Pioneer of the pioneers, he began, immediately following the close of the Civil War, the nursery business in Denmark, Iowa, when that flourishing state was a territory, a broad expanse of unbroken prairie over which the Sac and Fox Indians roamed at will. He assisted in establishing the first nursery in what is now Lee County, Iowa. He washed the seeds from which he grew his seedling apple trees from pomace of the cider mills on the hills overlooking the then village of Cincinnati, Ohio. These seedling trees were later June-budded, as it was before the art of root and collar grafting came into general practice. In that pioneer nursery he grew such varieties as Golden Pippen, Yellow Bellflower, Baldwin, Maiden Blush, Red June, Summer Rose, Summer Queen, Early Harvest, Autumn Strawberry, Rambo, Fall Wine, Moore Sweet, Roxbury Russet, Rhode Island Greening, Red Stripe, Ralls, Winesap, White Pearmain, Harrison, Yellow Newtown and Vandevere—not a bad list for so early a day. From that day until his death he kept pace with the pomological progress of this country.

Colonel Brackett has been styled "the father of Iowa horticulture" and was known as one of the most discriminating judges of fruits this country ever produced. Few have passed more useful and laborious lives. Gentle, honest, manly, his honorable, useful toil fully justifies the tribute paid him that "he left his enduring monument in thousands of farms and homes throughout America, under the broad, kind shelter of the trees that his hands or advice helped to plant and grow, and a grateful public will long revere his memory."

He was superintendent of pomology, Centennial Exposition, 1876; commissioner to Paris Exposition, 1878; representative of State of Iowa, Cotton States Exposition, New Orleans, 1885; representative of Division of Pomology, Department of Agriculture, at World's Columbian Exposition, Chicago, 1893; expert in horticulture, Exposition Universelle, Paris, 1900, where he received the decoration of the order of "Merite Agricole." He received many medals and diplomas at various times for expert work in horticulture. His name and fame as a pomologist were world wide.

Colonel Brackett was descended from that branch of the Brackett family (English Quakers) which settled at Portland, Maine, nearly 200 years ago, the branch of which the late speaker of the House, Thomas Brackett Reed, was a faithful exponent. New England history would be incomplete without the dominant part played by the Brackett family. Colonel Brackett leaves two brothers in Minnesota, Charles S. Brackett, a prominent business man of Minneapolis, and Arthur Brackett, of Excelsior, the well known horticulturist and member of the Minnesota State Horticultural Society. He was a gentleman of the old school, a friend in those old, old days when the world was young to us and Hope gave her winning smiles and Faith gave expanded vision. Beautiful orchards throughout this broad land are tributes to his wisdom, skill and influence. (*From the Minnesota Horticulturist.*)



COL. G. B. BRACKETT

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M. A. BLAKE.

PROCEEDINGS

...OF THE...

American Society

...FOR...

Horticultural Science

1916.

Thirteenth Annual Meeting

NEW YORK CITY.

December 28 and 29, 1916.

Published in March, 1917.

*Edited by the Secretary, C. P. Close,
College Park, Md.*

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OFFICERS AND COMMITTEES FOR 1917.

PRESIDENT.....	T. C. JOHNSON
VICE-PRESIDENTS.....	{ C. A. MCCUE
	{ S. W. FLETCHER
SECRETARY-TREASURER.....	{ W. T. MACCOUN
ASSISTANT SECRETARY.....	{ C. P. CLOSE
	{ C. E. DURST

EXECUTIVE

W. T. MACCOUN, <i>Chairman</i>	T. C. JOHNSON, President, <i>ex-officio</i>
M. A. BLAKE	C. P. CLOSE, Secretary, <i>ex-officio</i>
	J. K. SHAW

NOMINATING

J. P. STEWART, <i>Chairman</i>	J. H. GOURLEY
W. PADDOCK	A. W. DRINKARD, JR.
	J. W. CROW

PROGRAM

C. A. MCCUE, <i>Chairman</i>	C. P. CLOSE, <i>ex-officio</i>
C. E. MYERS	H. P. TOMPSON
C. G. WOODBURY	W. L. HOWARD
	H. P. STUCKEY

HORTICULTURAL COURSES

Undergraduate Course	Graduate Course
B. S. PICKETT, <i>Chairman</i>	M. J. DORSEY, <i>Chairman</i>
PAUL WORE	S. A. BEACH
W. L. HOWARD	J. C. WHITTEN

RESEARCH AND EXPERIMENTATION

H. J. WEBBER, <i>Chairman</i>	R. L. WATTS	A. C. BEAL
-------------------------------	-------------	------------

SCORE CARD

W. W. TRACY, SR., <i>Chairman</i>	T. C. JOHNSON	W. H. ALDERMAN
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MEMBERSHIP

C. E. DURST, <i>Chairman</i>	J. E. COIT	T. H. MCHATTON
C. P. CLOSE	A. J. FARLEY	J. G. MOORE
M. W. RICHARDS	R. W. REES	J. W. CROW

VARIETY TESTING.

J. H. GOURLEY	U. P. HEDRICK	S. A. BEACH
---------------	---------------	-------------

CONSTITUTION*

ARTICLE 1.

The name of this Association shall be the American Society for Horticultural Science.

ARTICLE 2.

The object of the Society shall be to promote the Science of Horticulture.

ARTICLE 3.

Any person who is a graduate of an agricultural college and holds an official position in an agricultural college, experiment station, or federal Department of Agriculture in the United States or Canada, may become a member upon payment of the annual dues of \$1.50.

ARTICLE 4.

Meetings shall be held annually at such time and place as may be designated by the Executive Committee, unless otherwise ordered by the Society.

ARTICLE 5.

The officers shall consist of a President, three Vice Presidents, and a Secretary-Treasurer, who, together with the chairmen of the standing committees, shall constitute a Council to act upon all applications for membership. There shall also be an Assistant Secretary. These officers shall be elected annually by ballot.

ARTICLE 6.

This Constitution may be amended by two-thirds vote of the Society at any regular meeting, notice of such amendment having been read at the last regular meeting.

BY LAWS*

Section 1. The President and other officers shall perform the usual duties of their respective offices. The President shall also deliver an address at each regular meeting.

Section 2. There shall be a Committee on Nominations consisting of five (5) members, who shall be nominated and elected by ballot at each regular meeting of the Society. It shall be the duty of this committee, at the following meeting, to suggest to the Society names for officers, referees, and members of committees for the ensuing year.†

Section 3. There shall be an Executive Committee, consisting of three (3) members and the President and the Secretary, ex-officio. This committee shall perform the usual duties devolving upon such committee.

Section 4. The Committee on Nomination shall nominate referees and alternates upon special subjects of investigation or instruction, which may be referred to its consideration by the Society. The duties of these referees shall be to make concise reports upon recent investigations or methods of teaching in the subjects assigned them, and to report the present status of the same.

Section 5. There shall be a Committee on Program, consisting of seven (7) members, of which the Secretary shall be one. This committee shall have charge of the scientific activities of the Society, except as otherwise ordered by the Society.

Section 6. There shall be a committee of five (5) members on co-ordination of the horticultural work of the U. S. Department of Agriculture and the Agricultural Colleges and Experiment Stations. (This committee was discontinued about 1912.)

Section 7. The annual dues of the Society shall be one dollar and fifty cents.

Section 8. Ten members of the Society shall constitute a quorum.

* The Constitution and By Laws as amended from time to time.

† Since 1913 two lists of candidates have been required.

MEMBERSHIP ROLL FOR 1916.

ALDERMAN, W. H.	Experiment Station, Morgantown, W. Va.
ALLEN, F. W.	Agricultural College, Pullman, Wash.
ANDERSON, J. P.	Alaska Agricultural Experiment Station, Sitka, Alaska.
ANSPON, B. W.	Maryland State College, College Park, Md.
ANTHONY, R. D.	Experiment Station, Geneva, New York.
AUCHTER, E. C.	Experiment Station, Morgantown, W. Va.
AUSTIN, C. F.	LaLaguna Plantation Co., Herradura, Cuba.
BABCOCK, E. B.	University of California, Berkeley, Calif.
BAILEY, E. W.	University of Illinois, Urbana, Ill.
BAILEY, L. H.	Ithaca, New York.
BALLARD, W. R.	Experiment Station, College Park, Md.
BARNETT, R. J.	State College of Washington, Pullman, Wash.
BARSS, A. F.	Agricultural College, Corvallis, Ore.
BATCHELOR, L. D.	Citrus Experiment Station, Riverside, Calif.
BEACH, S. A.	Iowa State College, Ames, Iowa.
BEAL, A. C.	Cornell University, Ithaca, New York.
BEATTIE, W. R.	174 Railway Exchange Bldg., St. Louis, Mo.
BECHTEL, J. R.	Pennsylvania State College, State College, Pa.
BECKENSTRATER, H.	Maryland State College, College Park, Md.
BENNETT, E. R.	Extension Service, Boise, Idaho.
BIOLETTA, F. T.	University of California, Berkeley, Calif.
BLAIR, W. S.	Experiment Station, Kentville, Nova Scotia.
BLAKE, M. A.	Experiment Station, New Brunswick, N. J.
BONNS, W. W.	Citrus Experiment Station, Riverside, Calif.
BRIELEY, W. G.	University Farm, St. Paul, Minnesota.
BROWN, B. S.	University of Maine, Orono, Maine.
CADY, LeROY.	University Farm, St. Paul, Minnesota.
CHANDLER, W. H.	Cornell University, Ithaca, N. Y.
CHENOWITH, W. W.	Agricultural College, Amherst, Mass.
CLARK, C. F.	U. S. Dept. Agr., Washington, D. C.
CLEMENT, F. M.	Univ. of British Columbia, Vancouver, B. C.
CLOSE, C. P.	U. S. Dept. Agr., Washington, D. C.
COIT, J. E.	University of California, Berkeley, Calif.
COLBY, A. S.	University of Illinois, Urbana, Ill.
CONDIT, I. J.	University of California, Berkeley, Calif.
CONNORS, C. H.	Experiment Station, New Brunswick, N. J.
CONOLLY, H. M.	U. S. Dept. Agr., Washington, D. C.
CORBETT, L. C.	U. S. Dept. Agr., Washington, D. C.
CORRIEVEAU, P. E.	Agricultural College, Kingston, R. I.
CRAIG, A. G.	Arandia Orchards Co., Deer Park, Wash.
CREELMAN, J. M.	Grimshy, Ontario, Can.
CRIDER, F. J.	Experiment Station, Clemson College, S. C.
CROW, J. W.	Agricultural College, Guelph, Canada.
CRUICKSHANK, R. R.	Ohio State University, Columbus, Ohio.
CULVERHOUSE, P. E.	Hort. Experiment Station, Vineland Station, Ontario, Can.
CUMMINGS, M. B.	Experiment Station, Burlington, Vt.
DACY, A. L.	Experiment Station, Morgantown, W. Va.
DARROW, G. M.	U. S. Dept. Agr., Washington, D. C.
DAVIS, V. H.	Ohio State University, Columbus, Ohio.
DEEING, CHARLES.	U. S. Dept. Agr., Washington, D. C.
DETJEN, L. R.	Experiment Station, West Raleigh, N. C.
DEWEY, G. W.	Jerome, Idaho.
DICKENS, ALBERT.	Agricultural College, Manhattan, Kansas.
DIVELBLISS, E. H.	Agricultural College, Roswell, N. M.
DORSEY, M. J.	University Farm, St. Paul, Minnesota.
DRINKARD, JR., A. W.	Experiment Station, Blacksburg, Virginia.
DURST, C. E.	University of Illinois, Urbana, Ill.

- ERWIN, A. T. Iowa State College, Ames, Iowa.
 EUSTACE, H. J. Agricultural College, East Lansing, Mich.
- FAGAN, F. N. Experiment Station, State College, Pa.
 FARLEY, A. J. Experiment Station, New Brunswick, N. J.
 FIOR, J. W. State College of A. and M. Arts, Athens, Ga.
 FISHER, D. F. Wenatchee, Wash.
 FITCH, C. L. Iowa State College, Ames, Iowa.
 FLETCHER, S. W. Penn. State College, State College, Pa.
 FLETCHER, W. F. U. S. Dept. Agr., Washington, D. C.
 FROST, H. B. Citrus Experiment Station, Riverside, Calif.
- GLADWIN, F. E. Vineland Laboratory, Fredonia, N. Y.
 GOULD, H. P. U. S. Dept. Agr., Washington, D. C.
 GOURLEY, J. H. Agricultural College, Durham, N. H.
 GRIMES, A. M. U. S. Dept. Agr., Washington, D. C.
- HALSTED, B. D. Experiment Station, New Brunswick, N. J.
 HANSEN, N. E. Agricultural College, Brookings, S. D.
 HEDRICK, U. P. Experiment Station, Geneva, N. Y.
 HEINICKE, A. J. Cornell University, Ithaca, N. Y.
 HENRICKSEN, A. P. University Farm School, Davis, Calif.
 HEPLER, J. R. University of Wisconsin, Madison, Wis.
 HERRICK, R. S. Iowa State College, Ames, Iowa.
 HIGGINS, J. E. Experiment Station, Honolulu, Hawaii.
 HOLLISTER, S. P. Agricultural College, Storrs, Conn.
 HOLMES, F. S. Experiment Station, College Park, Md.
 HOOD, G. W. University of Nebraska, Lincoln, Nebraska.
 HOSHINO, YUZO. The Tohoku Imperial University, Sapporo, Japan.
 HOWARD, R. F. University of Nebraska, Lincoln, Neb.
 HOWARD, W. L. University Farm School, Davis, Calif.
 HOWE, G. H. Experiment Station, Geneva, N. Y.
 HUBER, H. F. Experiment Station, New Haven, Conn.
 HUME, H. H. Glen St. Mary, Florida.
 HUSMANN, F. L. Second and Seminary Streets, Napa, Calif.
 HUSMANN, G. C. U. S. Dept. Agr., Washington, D. C.
 HUTT, W. N. State Department of Agriculture, Raleigh, N. C.
- JENKS, A. R. 82 Hall Street, Springfield, Mass.
 JOHNSON, T. C. Virginia Truck Experiment Station, Norfolk, Va.
 JONES, D. F. Experiment Station, New Haven, Conn.
- KEYSER, C. N. State College of Agriculture, Athens, Ga.
 KILHAM, A. D. Massachusetts Agricultural College, Amherst, Mass.
 KNOX, J. S. Old State House, Little Rock, Ark.
 KRAUS, E. J. Experiment Station, Corvallis, Oregon.
 KYLE, E. J. A. & M. College of Texas, College Station, Texas.
- LAKE, E. R. U. S. Dept. Agr., Washington, D. C.
 LANHAM, W. B. A. & M. College of Texas, College Station, Texas.
 LEE, J. G. Agricultural College, Baton Rouge, La.
 LEWIS, C. I. Agricultural College, Corvallis, Oregon.
 LLOYD, J. W. University of Illinois, Urbana, Ill.
 LOCKLIN, H. D. Agricultural College, Corvallis, Oregon.
 LOMBARD, P. M. U. S. Dept. Agr., Washington, D. C.
 LOMMEL, W. E. Purdue University, Lafayette, Ind.
 LUMSDEN, DAVID. Cornell University, Ithaca, N. Y.
 LURIE, A. Missouri Botanical Garden, St. Louis, Mo.
- MACKINTOSH, R. S. University Farm, St. Paul, Minn.
 MACOUN, W. T. Central Experiment Farm, Ottawa, Canada.
 MANEY, T. J. Iowa State College, Ames, Iowa.
 MARKELL, E. L. 55 Liberty St., New York, N. Y.

- MATHEWS, C. D. State Dept. of Agr., Raleigh, N. C.
 MATHEWS, C. W. Agricultural College, Lexington, Ky.
 MCCLINTICK, J. A. Virginia Truck Experiment Station, Norfolk, Va.
 McCUE, C. A. Experiment Station, Newark, Del.
 MCGINTY, R. A. College of Agriculture, Fort Collins, Colo.
 MCHATTON, T. H. State College of A. & M. Arts, Athens, Ga.
 MILLER, P. E. U. S. Dept. Agr., Washington, D. C.
 MILWARD, J. G. University of Wisconsin, Madison, Wis.
 MONTGOMERY, L. M. Ohio State University, Columbus, Ohio.
 MOORE, J. G. Experiment Station, Madison, Wis.
 MORRIS, O. M. Experiment Station, Pullman, Wash.
 MULFORD, F. L. U. S. Dept. Agr., Washington, D. C.
 MYERS, C. E. Experiment Station, State College, Pa.
 NELSON, AVEN. Experiment Station, Laramie, Wyo.
 ORTON, W. A. U. S. Dept. Agr., Washington, D. C.
 OSKAMP, JOS. Purdue University, Lafayette, Ind.
 OVERHOLSER, E. L. Cornell University, Ithaca, N. Y.
 PADDOCK, W. Ohio State University, Columbus, Ohio.
 PAILTHORPE, R. R. Experiment Station, Newark, Del.
 PALMER, W. E. Purdue University, Lafayette, Ind.
 PELTON, W. C. Georgetown, Del.
 PETERSON, W. A. Northern Great Plains Field Station, Mandan, N. D.
 PFANDER, MAX. Northern Great Plains Field Station, Mandan, N. D.
 PICKETT, B. S. University of Illinois, Urbana, Ill.
 PILLSBURY, J. P. Experiment Station, West Raleigh, N. C.
 POTTER, G. F. University of Wisconsin, Madison, Wis.
 PRATT, B. B. Box 642, Station C, Los Angeles, Cal.
 PRICE, H. L. Experiment Station, Blacksburg, Va.
 PRICE, J. C. C. Alabama Polytechnic Institute, Auburn, Ala.
 RALSTON, G. S. Virginia Polytechnic Institute, Blacksburg, Va.
 REED, C. A. U. S. Dept. Agr., Washington, D. C.
 REES, R. W. Cornell University, Ithaca, N. Y.
 REHDER, ALFRED. Arnold Arboretum, Jamaica Plain, Mass.
 REIMER, F. C. Southern Oregon Experiment Station, Talent, Ore.
 RICHARDS, M. W. Purdue University, Lafayette, Ind.
 RIDLEY, V. W. U. S. Dept. Agr., Washington, D. C.
 ROBB, O. J. Horticultural Exp. Station, Vineland Station, Ontario, Can.
 ROBERTS, R. H. University of Wisconsin, Madison, Wis.
 ROLFS, P. H. Experiment Station, Gainesville, Fla.
 ROSA, J. T., JR. Virginia Truck Experiment Station, Norfolk, Va.
 SAUERS, C. G. Purdue University, Lafayette, Ind.
 SAYRE, C. B. Purdue University, Lafayette, Ind.
 SCHERREB, J. B. New Hampshire College, Durham, N. H.
 SCHMIDT, D. Experiment Station, New Brunswick, N. J.
 SCOTT, L. B. U. S. Dept. Agr., Washington, D. C.
 SEARS, F. C. Agricultural College, Amherst, Mass.
 SHAW, J. K. Experiment Station, Amherst, Mass.
 SHAW, PERCY J. Agricultural College, Truro, Nova Scotia.
 SHAW, S. B. Maryland State College, College Park, Md.
 SHOEMAKER, D. N. U. S. Dept. Agr., Washington, D. C.
 SMITH, EDWIN. Dominion Department of Agriculture, Grimsby, Ont.
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 STARCHER, G. C. Experiment Station, Auburn, Ala.
 STARBING, C. C. Agricultural College, Bozeman, Mont.
 STEWART, JOHN P. Experiment Station, State College, Pa.
 STODDARD, E. F. Maryland State College, College Park, Md.

- STUART, WM.....U. S. Dept. Agr., Washington, D. C.
 STUBENRAUCH, A. V.....University of California, Berkeley, Cal.
 STUCKEY, H. P.....Experiment Station, Experiment, Ga.
 SUTTON, F. J.....Purdue University, Lafayette, Ind.
 SUTTON, L. F.....Experiment Station, Morgantown, W. Va.

 TAYLOR, R. H.....University of California, Berkeley, Cal.
 TAYLOR, W. A.....U. S. Dept. Agr., Washington, D. C.
 THAYER, PAUL.....Experiment Station, Wooster, Ohio.
 THOMPSON, H. C.....U. S. Dept. Agr., Washington, D. C.
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 TRACY, SR., W. W.....U. S. Dept. Agr., Washington, D. C.
 TRUAX, H. F.....U. S. Dept. Agr., Washington, D. C.
 TUFTS, W. P.....University Farm, Davis, Cal.
 TURNER, A. C.....Dept. Agr., Fredericton, New Brunswick.

 VOLZ, E. C.....Cornell University, Ithaca, N. Y.
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 WATSON, B. M.....Summer Street, Plymouth, Mass.
 WATKINS, O. S.....University of Illinois, Urbana, Ill.
 WATTS, R. L.....Experiment Station, State College, Pa.
 WEBBER, H. J.....Citrus Experiment Station, Riverside, Cal.
 WELLINGTON, J. W.....Experiment Station, Geneva, N. Y.
 WELLINGTON, R.....University Farm, St. Paul, Minn.
 WERNER, H. O.....Experiment Station, Agricultural College, N. D.
 WHITE, E. A.....Cornell University, Ithaca, N. Y.
 WHIPPLE, O. B.....Experiment Station, Bozeman, Mont.
 WHITTEN, J. C.....Experiment Station, Columbia, Mo.
 WIGHT, W. F.....U. S. Dept. Agr., Washington, D. C.
 WHYTE, R. B.....370 Wellrod St., Ottawa, Canada.
 WICKS, W. H.....Experiment Station, Fayetteville, Ark.
 WILSON, C. S.....State Dept. of Agr., Albany, N. Y.
 WINSLOW, R. M.....Dept. of Agr., Victoria, B. C.
 WOODBURY, C. G.....Purdue University, Lafayette, Ind.
 WORK, PAUL.....Cornell University, Ithaca, N. Y.
 WRIGHT, W. J.....Alfred University, Alfred, N. Y.

TREASURER'S REPORT FOR 1916.

Voucher No.		Cr.	
	1915.		
1	Dec. 31	To expenses of C. P. Close, Secretary, to Columbus Meeting, December 28 and 29, 1915.....	\$39.46
	Jan. 11	" Stamps	4.00
	1916.		
	Jan. 18	" Stamps	2.00
2	Jan. 25	" Express on manuscript of 1915 report to printer in Annapolis, Md.	.25
3	Feb. 1	" Express on letterheads, envelopes, and report envelopes from printer in Annapolis.....	.55
		" Stamps	2.00
4	Feb. 9	" Half-tone plate of W. L. Howard for 1915 report....	2.00
	Feb. 24	" Stamps	1.00
5	Feb. 29	" One-half of cost of cut of Col. Brackett (1915 report)	1.00
	Mar. 1	" Stamps	2.00
	Mar. 16	" Stamps	2.00
6	Mar. 17	" Express on 1915 reports	1.32
	Mar. 17	" Postage on 1915 reports.	14.38
	Mar. 22	" Stamps	2.00
7	Apr. 6	" W. M. Holladay, 2500 letterheads, 2500 envelopes....	16.00
8	Apr. 6	" W. M. Holladay, 600 No. 70 Columbia Clasp envelopes	\$5.25
		300 copies 1915 report	\$173.40
			178.65
	May 24	To Stamps	2.00
	Sep. 12	" Stamps	1.00
	Oct. 11	" Stamps	1.00
9	Oct. 11	" Bill of C. E. Durst, letterheads and envelopes	\$4.50
		Stamps to date	6.70
		Stenographic help	3.38
			14.58
	Oct. 23	To Stamps	2.00
	Dec. 6	" Stamps	2.00
	Dec. 15	" Stamps	1.00
	Dec. 19	" The Torsch & Franz Badge Co., 150 buttons for 1916.	4.05
	Dec. 26	" Stamps	1.00
			\$297.24

Dr.

	1915.		
Dec. 28	By	Balance on hand.....	\$210.95
Dec. 28	"	H. W. Lutz, Ohio State University, Columbus, Ohio, report 1915	1.00
Dec. 28	"	R. A. VanMeter, Ohio State University, Columbus, Ohio, report 1915	1.00
Dec. 28	"	J. M. Veazey, Ohio State University, Columbus, Ohio, report 1915	1.00
	1916.		
Jan. 20	"	J. H. Gourley, Experiment Station, Durham, N. H., reports 1906, 1907, 1908-9, 1910.....	4.00
Jan. 20	"	Alabama Polytechnic Institute, Auburn, Ala., reports 1911, 1912, 1913, 1914.....	4.00
Jan. 22	"	Paul Thayer, Experiment Station, Wooster, Ohio, first ten reports	10.00
Jan. 24	"	A. C. McClurg & Co., Chicago, Ill., first ten reports.....	10.00
Feb. 5	"	Purdue University, Lafayette, Ind., report 1914.....	1.00

1915.

Feb.	8	By J. H. Gourley, Experiment Station, Durham, N. H., report 1903-4	\$1.00
Feb.	8	" W. T. Macoun, Central Experimental Farm, Ottawa, Canada, report 1914	1.00
Feb.	19	" Brooklyn Institute of Arts & Science, Brooklyn, N. Y., first ten reports	10.00
Feb.	19	" Prof. Yuzo Hoshino, the Tohoku Imperial University, Sapporo, Japan, first eleven reports	11.00
Mar.	6	" W. D. Boyce Co., 500 North Dearborn St., Chicago, Ill., report 1914	1.00
Mar.	17	" State Department of Agriculture, Harrisburg, Pa., report 1915	1.00
Mar.	21	" Thomas A. Dungan, 47 W. Garfield Blvd., Chicago, Ill., report 1915	1.00
Mar.	27	" Oklahoma Agricultural Experiment Station, Stillwater, Okla., first ten reports	10.00
Mar.	29	" Brooklyn Institute of Arts & Science, Brooklyn, N. Y., report 1915	1.00
Mar.	31	" Iowa State College, Ames, Iowa, report 1915	1.00
Apl.	1	" University of Minnesota, University Farm, St. Paul, Minn., report 1915	1.00
Apl.	1	" U. S. Department of Agriculture, Washington, D. C., (for Mandan Station) first eleven reports	11.00
Apl.	3	" Georgia State College of Agriculture, Athens, Ga., report 1915	1.00
Apl.	6	" Ohio State University, Columbus, Ohio, report 1915	1.00
Apl.	6	" Ohio Agricultural Experiment Station, Wooster, Ohio, report 1915	1.00
Apl.	7	" Georgia Experiment Station, Experiment, Ga., report 1915	1.00
Apl.	10	" Virginia Polytechnic Institute, Blacksburg, Va., reports 1914 and 1915	2.00
Apl.	11	" Utah Agricultural College, Logan, Utah, report 1915	1.00
Apl.	17	" State College of Washington, Pullman, Wash., report 1915	1.00
Apl.	18	" University of Wisconsin, Madison, Wis., report 1915	1.00
Apl.	19	" Cornell University, Ithaca, N. Y., report 1915	1.00
Apl.	19	" Rutgers College, New Brunswick, N. J., report 1915	1.00
Apl.	22	" A. & M. College of Texas, College Station, Tex., report 1915	1.00
Apl.	22	" A. C. McClurg & Co., 330 E. Ohio St., Chicago, Ill., report 1915	1.00
Apl.	22	" Macdonald College, Macdonald College P. O., Quebec, Canada, report 1915	1.00
Apl.	24	" Purdue University, Lafayette, Ind., reports 1913, 1914, 1915	3.00
Apl.	24	" G. E. Stechert & Co., 151 25th St., New York City, first eleven reports	11.00
Apl.	24	" Massachusetts Agricultural College, Amherst, Mass., report 1915	1.00
Apl.	24	" University of Maine, Orono, Me., report 1915	1.00
Apl.	28	" University of Nebraska, Lincoln, Neb., report 1915	1.00
Apl.	28	" The Baker & Taylor Co., New York City, report 1915	1.00
May	2	" University of California, Berkeley, Cal., report 1915	1.00
May	2	" Iowa State College, Ames, Iowa, report 1914	1.00
May	8	" Kentucky Agricultural Experiment Station, Lexington, Ky., report 1915	1.00
May	11	" Oregon Agricultural College, Corvallis, Ore., report 1915	1.00
May	23	" Southern Oregon Experiment Station, Talent, Ore., report 1915	1.00
May	31	" University of California, Berkeley, Cal., report 1915	1.00
May	31	" University of Vermont, Burlington, Vt., report 1915	1.00

1915.			
June 6	By Hawaii Experiment Station, Honolulu, Hawaii, report 1915		\$1.00
June 6	" State Agricultural College, Fort Collins, Colo, report 1915		1.00
June 15	" University of Missouri, Columbia, Mo., report 1915.....		1.00
June 17	" Pennsylvania State College, State College, Pa., report 1915		1.00
June 30	" W. Worthington, 4041 Arcade Building, Seattle, Wash., report 1915		1.00
July 7	" Purdue University, Lafayette, Ind., report 1915.....		1.00
July 20	" New Mexico College of Agriculture & Mechanical Arts, State College, N. M., report 1915.....		1.00
July 25	" Kansas State Agricultural College, Manhattan, Kan., reports 1912, 1913, 1914, 1915.....		4.00
July 29	" University of Idaho, Moscow, Idaho, report 1915.....		1.00
Sept. 12	" H. O. Werner, Experiment Station, Agricultural College, N. D., set of eleven reports.....		11.00
Oct. 9	" James C. Waters, Jr., Rahway, N. J., report 1914.....		1.00
Oct. 26	" Georgia State College of Agriculture, Athens, Ga., reports 1908-9, 1912, 1914.....		3.00
Nov. 3	" University of Arkansas, Fayetteville, Ark., first eleven reports		11.00
Nov. 28	" University of California, Berkeley, Cal., report 1915.....		1.00
Nov. 28	" Louisiana State University, Baton Rouge, La., report 1915		1.00
Nov. 28	" University of Arizona, Tucson, Ariz., reports 1912, 1913 1914, 1915		4.00
Dec. 2	" University of Idaho, Moscow, Idaho, report 1914.....		1.00
Dec. 4	" Maryland State College, College Park, Md., reports 1911, 1912, 1913, 1914, 1915.....		5.00
Dec. 7	" Pennsylvania State College, State College, Pa., reports 1903 4, 1905, 1906, 1907, 1908-9.....		5.00
Dec. 28	" Annual dues paid during the year.....		284.50
			\$671.45
Balance on hand.....			
			\$374.21

Respectfully submitted,

C. P. CLOSE, Treasurer.

The Auditing Committee reported that it had examined the accounts of the Treasurer and found them to be correct.

C. A. McCUE,

T. C. JOHNSON,

J. P. STEWART,

Committee.

ANNUAL MEETING AT NEW YORK, N. Y.

1916

THURSDAY, DECEMBER 28, 10:00 A. M.

The meeting was called to order by President Blake. There was a good attendance throughout the two days' sessions, the papers and discussions were excellent, and the general sentiment of the members was that this was the best meeting ever held by the Society.

METHODS OF WORK IN PRUNING INVESTIGATIONS.

BY C. H. CONNORS, *Experiment Station, New Brunswick, N. J.*

One of the objects of the founding of the American Society for Horticultural Science was the exchange of ideas and methods in scientific investigations in horticulture. Heretofore, results have been the main topic of most of the papers, only a few having dealt with methods.

The peach pruning experiments here outlined form one of the most extensive projects undertaken by the Horticultural Department of the New Jersey Experiment Station, and it was thought that an outline of the methods pursued might be of interest to the members of this Society.

Peaches have been and are still grown in New Jersey on a large scale, and under different soil and climatic conditions. This variation in soils made it very desirable to duplicate the experiments as a check, since the growth of peaches on different types of soil shows a marked difference and it was expected that this difference would affect the pruning treatments. One of the experiments was accordingly located at Vineland on ground adjacent to the fertilizer experiments already established, the soil being a sandy and gravelly loam. The other was located on the College Farm at New Brunswick on a gravelly Penn loam soil. This soil is the common red clay of the Trenton area, and is composed mainly of clay with a large percentage of silt.

SELECTION OF VARIETIES.

In selecting the varieties to be used in these experiments, it was necessary first to choose commercial varieties, in order to make the experiments of practical value. A second consideration was the selection of varieties having different habits and character of growth. Third, the season of ripening was recognized as an important factor if any summer pruning was to be practiced.

Three varieties, Carman, Elberta and Stump, were chosen as being typical of most of the commercial varieties. Carman is spreading in habit of growth, has strong twigs and is early in ripening. Elberta is a mid-season variety of an upright spreading habit, with rather stock twigs, but is not an especially vigorous grower. Stump, a white-fleshed variety, ripening just after Elberta, of the Crawford habit of growth, is upright and vigorous, but usually has slender twigs.

SELECTION OF PRUNING TREATMENTS.

While there are a comparatively few growers who do no pruning at all, investigators all recommend some style of pruning. These recommendations fall into two groups:

1: Pruning that would affect the growth of a tree or alter its form; and

2: Pruning that is so slight as to be almost negligible. The season of pruning is also to be considered.

The widest variation in pruning practices are between the cut-back method and the not cut-back. The mechanical strength of the tree is also involved, but no attempt is made to study this problem specifically in the present experiments, although it is to be studied incidentally as the various types are fairly well represented in the various treatments selected.

Obviously it was impossible to include all the ideas and theories of the growers in these experiments, so four pruning treatments were selected that, with the check, would represent the various methods recommended:

(1) "Not pruned," in which no pruning is done except to remove dead twigs and branches during the dormant season.

(2) "Winter not cut-back," whereby the trees are allowed to assume the natural habit of growth, the only pruning being to remove twigs and branches that interfere and to thin so as to admit light to the tree, all pruning being done during the dormant season.

(3) "Winter cut-back," in which the trees are pruned during the dormant season the treatment consisting of thinning twigs and branches to admit light to the center of the tree, and of cutting back the leaders and side branches.

(4) "Winter and Summer," a system similar to the "Winter cut-back," with the addition of at least one "pinching back" of twigs during the growing season.

(5) "Summer only," essentially the same as the two preceding treatments as to form, except that all pruning is done during the growing season.

A large enough number of individuals was planted to anticipate any loss through disease or other causes. At Vineland ten plots were planted, two plots for each treatment, so arranged as to check differences in soil. Five trees of each variety were planted on each plot.

At New Brunswick, nine plots were planted; one "not pruned" and two of each of the other four. Each plot contained three Elberta, two Stump and three Carman.

CULTURAL TREATMENT.

The plots are all given the same cultural treatment. A complete fertilizer is applied in the spring and clean cultivation is practiced from the spring plowing until the middle of August, when a leguminous cover crop is sown. The usual spray calendar for peaches is followed, applications being made for scale and leaf curl in the dormant seasons and four or five summer sprays for curculio, scab, and brown rot.

MEASUREMENTS.

In order to arrive at some basis of comparison as to the relative growth of the trees in the various treatments, the circumference of the trunk of each tree is measured at about six inches from the ground. Some of the trees, however, were allowed to branch at or below this point, thus excluding these trees from this system of measurement. It was previously observed that trees sometimes made a top growth that was apparently not compatible with the increase in trunk circumference. If this be true, the circumference of the trunk would not form a certain basis for comparison, and so each year the actual growth in inches of each twig is taken. The measurement of the amount pruned off deducted from the total twig growth leaves the amount available for fruit production. These data will also serve to show whether or not there is any relation between inches of twig growth and inches increase in circumference.

In addition to the measurements above mentioned, the height of the tallest twig and the width through the widest part of the tree and the height from the ground at which the widest diameter occurred have been taken since the third season.

Analysis is made of twigs to determine the amount of dry matter contained therein as affected by the difference in variety and pruning treatment.

METHOD OF HARVESTING.

From a commercial point of view, the value of the pruning experiment must be estimated by the relation of the various systems of pruning to the amount and quality of the fruit crop and the economy of orchard management. Under the "not pruned" treatment the lower branches are allowed to remain while in the other system they are removed so as to clear the ground by about three feet. Two questions are involved: (1) Is the fruit borne on the lower branches of commercial importance? (2) Will the height of fruit production become stable or will it ascend with the growth of the tree?

The following system of harvesting the fruit is used: During the dormant season the trees are marked off vertically into zones beginning at one foot from the ground and then every foot up to the tip of the bearing wood. The markings are made by ringing the twigs and branches with white paint. The fruit is picked, when mature, zone by zone.

To arrive at the quality and size of the crop borne, the production of each zone is counted and weighed, and from tables previously prepared the average size of the fruits is determined from the average weight. Notes are made of the quality as regards color and blemishes at the time of picking. After the June drop, the trees in the plots are thinned, the time required being noted and the number of the immature fruits removed from each variety on each plot is calculated on a basis of average weight.

FURTHER ECONOMIC DATA.

Each time the orchard is sprayed, a record is made of the amount of spray material used on each row and the time required to apply it.

The time required to prune each tree is also taken, the pruning each time being done by the same person or under his direct supervision.

In addition, the life history of a number of individuals in the experiment is kept by means of photographs taken each year before and after pruning. Specimens were selected that would show as far as possible the ideals for the various treatments, as established by the investigators.

MONOGRAPHIC STUDIES WITH FLOWERS.

BY A. C. BEAL, *Cornell University, Ithaca, N. Y.*

After the organization of the experiment stations, the subject of variety-testing received considerable attention for a few years, but in recent times there has been a tendency to belittle the importance of any study of varieties. One reason for this attitude is based on the heterogeneous character of much of this early work. It appears to have been assumed that the season's novelties in fruits, vegetables and flowers could be sent to a poor defenseless station horticulturist who could give each his undivided attention during growth, and finally render expert opinion upon the merits of each aspirant for popular favor. As we look back upon this period, the wonder is that the horticulturists acquitted themselves as well as they did. Of course, after five or ten years of this thing, they concluded that each year began and ended at about the same spot and that little or no progress was being made. The whole trouble was that miscellaneous testing did not arrive anywhere. A close parallel would be the results secured if soil experts, in obtaining a knowledge

of the soils of the state, contented themselves with miscellaneous scattered samples sent in by farmers instead of acquiring their information by means of systematic and thorough surveys. If the old-type variety studies are similar to work of the former, the new-type variety studies are at least comparable to the soil surveys.

Another reason for the decline of this work may be due, to some extent, to the fact that horticulturists reflect the general attitude toward taxonomic work. It has been complained that the modern scientist regards the taxonomist as unscientific. So far as this attitude affects work with plants, it is very short-sighted; for without absolute accuracy in the names of the plants employed in any experiment, any scientific superstructure (no matter how perfect otherwise) is reared on shifting sand.

Likewise, some horticulturists appear to take somewhat the same attitude toward any consideration of varieties. Even a little thought upon the subject should convince anyone that the variety is a cornerstone of success in practical work. Unless the variety is adapted to the soil and climate, and meets the market requirements, even unusual cultural skill will go unrewarded. Cultural practices must be modified to satisfy peculiar varietal requirements. If we admit, then, the importance of the variety as a factor in success, and also its influence upon methods of practice, why should not a true horticulturist study varieties? It would seem that the man who regards the work as unscientific is only advertising his own superficiality or lack of proper perspective.

An examination of the investigations along this line reveals the fact that some excellent work has been done with fruits and vegetables. Since Cornell University has done more with flowers than has any other institution, it was thought desirable to present something concerning our methods of work.

Our first and most important studies upon flowers are the result of co-operation between floricultural societies and the department of floriculture, or its predecessor the department of horticulture. The society in each case has contributed the seeds, bulbs or plants, or has used its influences to secure the material from foreign growers. The work upon peonies, sweet peas, gladioli and roses, has been carried out under co-operative arrangements of this kind. If the work has been successful, much credit is due the societies for their support. The work on all these subjects, except the latter, has been in charge of graduate students, usually those who were candidates for the doctor's degree. This arrangement has probably succeeded because none of the work has been entrusted to any but mature or brilliant students. It may be noted, also, that these men have been connected with the departmental staff as assistants or instructors, and therefore not under great financial pressure to finish their work in a minimum time.

The investigations on the phlox and iris differ in not being supported by special societies, but the material has been contributed by interested growers.

If competent students are entrusted with the work, which is as carefully supervised as all graduate work should be, no difficulty will be experienced in properly handling it unless the problem is so large that the first man cannot bring it to reasonable completion. There is a loss of efficiency in transferring an investigation of this type to another person. Some time is lost while the second man attains a thorough grasp of the subject. Interruptions of this kind may lead to friction between the organization and the department. All large investigations should be placed in the hands of men who are permanent, and only such pieces of work entrusted to assistants as may be reasonably completed in three years. I have alluded to this matter because it is exceedingly important in co-operative work, but should also be taken into consideration in undertaking any studies of this kind. I think we will agree that those stations which have done most in variety studies with tree fruits have been those which have had the fewest changes in supervision and have given most careful consideration to selection of men to continue the investigations.

After the problem has been assigned or has been chosen by a student, what is the first step? In our experience we would say, study all of the available literature. If the time is short before planting must begin, a rapid survey will enable the investigator to get a grasp of the botany and evolution of the plant. A card index of all the existing varieties and species in current trade lists is made. Efforts are made to secure varieties that are not contributed by the members of the society. Not all the growers of any crop are members of horticultural societies, nevertheless they may be very much in sympathy with the objects of the investigation. Correspondence is opened up with botanical gardens and other collectors for the purpose of securing as many species as possible, even though they may require glass protection. The best methods of culture for the different species or types must be ascertained from publications and by correspondence. The minimum number of plants which will afford a fair test is grown. This is important if the number of varieties is large or if many of them are expensive. The material sent in should be given an accession number or a field number, and be kept track of by number rather than by name. Unnamed seedlings or novelties, of which there may not be a published description, should be accompanied by as complete a description as the donor can give. This information is necessary for a proper arrangement of the varieties on the trial grounds, for if the various lots of material can be classified so as to bring together those of similar color, etc., much time may be saved. If grown side by side, suspected synonyms may be definitely determined; whereas if grown elsewhere, even in the same plot, there may be some reason to doubt the final conclusion.

A very important consideration is the kind of data to be taken and the method of recording. With flowers that are in bloom but a short while, the time element in recording data must not be ignored. We have found it desirable to use description cards or blanks for

rapid recording in the field. These cards are prepared by a study of the structure of the flower and of the characters of the plant. A study of the best descriptions in journals and catalogues will yield the student a collection of descriptive terms which he can sift with his knowledge of botany. A tentative blank is then prepared and tested in practice. It is then revised and again tested before the card is printed. The use of the descriptive card insures that each plant character will receive consideration in studying each variety. Without it, unusual or outstanding features or characters may receive undue attention while others may be forgotten. It scarcely need be said that every bit of information concerning the success or failure of a variety should be recorded. The susceptibility to disease or insect attack should also be noted. In all the work, while recording data in the field, no attention should be paid to any published descriptions of the varieties included in the test. As far as possible, the descriptions should be made independently, and to eliminate the influence of publications issued by interested persons the varieties are grown under numbers.

The chief criticism of existing descriptions of flowers is the lack of system in color nomenclature. It is probable that there is nothing upon which there is as great difference of opinion as color. A color standard is employed, and the flower colors carefully compared. We have used the *Repertoire des Couleurs*, published by Rene Oberthur et Henri Dauthenay, under the auspices of the French Chrysanthemum Society. It was adopted by the Royal Horticultural Society of Great Britain, the American Peony Society and the American Gladiolus Society. More recently Ridgeway's Chart appeared, and there has been an unusual effort to get this adopted. The agitation for the most part has been directed by persons who have never seen the first-mentioned chart or who have had little or no experience in using any chart in any extensive way. My own experience with the latter chart is that it is deficient in reds, but more satisfactory in lavenders and blues. It is more convenient to use, more expensive and offers a smaller bit of color against which to match. It is claimed that the Ridgeway Chart is scientifically prepared, and therefore it can be more accurately reproduced. For certain kinds of work, doubtless it is very satisfactory; but it does not seem to have been prepared with flower colors in mind. Thus far we prefer to use the standard that has some official recognition from horticultural bodies and which in general has proved, after thousands of color determinations and comparisons, to be most satisfactory. After all, the important thing is to use some readily available standard so that when a color is said to be Tyrian rose or lilac rose, we may know exactly what is meant.

As soon as possible, each description should be written out as if for publication. If the flower is one which has a long period of bloom, this should be done before the end of the season. At the end of the year we find it desirable to send a report to those who sent in seedlings or novelties. Sometimes the record will be questioned, but in almost every case it resulted in a new consignment

of stock for further trial. Such consignments should be tested side by side with the previous shipment. These cases are carefully watched as they bloom, and if the points in question are apparent in the second lot the description is altered. If the two agree and do not show characteristics claimed by the grower, he is asked to send in sample blooms. This is done not so much to help out any individual, but to protect the co-operating organizations and through them the flower-buying public. The aim in all this work is the distinctiveness of the variety and its right to exist and bear a name. In our *gladiolus* investigations we have been peculiarly fortunate in having received a large number of unnamed seedlings for testing alongside the large collection of named varieties. Our judgment has been followed, I think without an exception, and we feel that we have aided in reducing, to some extent, the list of new varieties which might have been offered.

Each year the descriptions are checked up with those made the previous year, and the differences, if any, are recorded. Throughout the work the idea of classification is not lost sight of, and characters which may be used to throw the varieties into groups are sought. These characters should be readily apparent and therefore easily understood by the grower. All kinds of plants with many varieties are usually susceptible of some kind of grouping or classification. The one that has given us most trouble is the *gladiolus*. In this even the old characters of *Gandavensis* Lemoinei, *Nanceianus* and *Childsii* no longer hold because they have been lost through crossing. No classification we could make will hold, so in despair after six years' study we have published alphabetically the very long list of the varieties of this flower. Each description is published complete and includes information as to the originator, introducer, donor, the synonyms, if any; and when it can be referred to any of the above-mentioned groups, it is so referred.

If the work has been thoroughly done and the worker persistent in securing varieties of all existing types as well as all the available species, and if he has carefully studied all the plates, cuts and figures of the obsolete types, he has the most thorough knowledge possible of what the evolution of the plant has been. In fact, he will have much of the evidence right before his eyes when he is in the field so that if he lives with his problems, he should know at least one plant thoroughly. Thus he acquires his facts and should be able to organize and present them in something like monographic form. The work is taxonomic in character differing chiefly in the fact that the varieties are grown together at one place and also because no studies are made on dead plants if a live plant is obtainable. We are aware of the drawbacks to a concentration at one point and wish to say that in every case thus far we have not published any floricultural monograph that did not include some studies made outside of Ithaca.

Nomenclature questions arise and must be settled. If they could be settled by the application of the rule of priority in the offhand manner used by the botanists, the question would be simplified; but,

unfortunately, in these cases the investment is often considerable and a decision in the matter is far-reaching if it has weight at all. After a good many years' experience on nomenclature committees, I want to say that there is a remarkably fine spirit among the florists to do anything to clarify existing nomenclature. The same experience has shown that registration without testing is worthless except with forcing varieties of roses, carnations and chrysanthemums which are at present very closely supervised by the societies especially interested. The great mass of flower novelties do not have to pass such critical examination. If monographic studies exert their maximum influence for good, they should serve as a basis for the solution of vexing questions of nomenclature.

In conclusion, it may be said that a study of this kind properly carried out will be found to fairly bristle with all kinds of problems concerning the growth and care of the plants. Instead of being the end, it will be for the person who loves the plants he has dealt with, only a beginning.

GARDENIA STUDIES.

By C. H. CONNORS, *Experiment Station, New Brunswick, N. J.*

The gardenia (*Gardenia Veitchii*) is a special greenhouse crop which is not grown as commonly as roses and carnations due partly to the fact that the culture of the plant is somewhat difficult and the so-called secrets of handling it are retained by the successful growers, and partly to the high price of the blooms, which naturally precludes a wide demand.

Perhaps the greatest trouble encountered in the cultivation of this plant is that known as "yellowing." This yellowing of the foliage sometimes is present on the young stock in pots, but it usually occurs on the plants in the benches from the middle of the season on. This yellowing is of two kinds. The leaves of the growing parts take on a yellowish appearance, the veins remaining green. A later stage is the formation of brown spots much like burning along the margin of the leaves. In the second form, the old leaves are mottled with orange-yellow. As a result of this discoloration the leaves cannot function, and restricted growth and malformed flowers ensue, with dropping of the buds, and shedding of the leaves in the case of the second kind and in the case of the first of the extreme burned-like appearance. A yellow condition of foliage occurs with other greenhouse plants. Yellowing of the foliage of American Beauty roses can be induced by excessive nitrogen and by soil acidity. Killarney roses are particularly susceptible to soil acidity, the foliage becoming yellow with a slight percentage of acidity.

The cause of "yellowing" in gardenias has been ascribed to an infectious disease and to "club root."

In the spring of 1915, a grower of gardenias on an extensive

scale called the attention of the Horticultural Department of the New Jersey Experiment Station to the very yellow condition of the foliage on the flowering plants in the beds, and also upon the young stock recently propagated for the next season's planting, and desired to know the reason for it.

An attempt was made to determine the cause by inspection. The plants were growing in a rather sticky clay soil that dried out slowly. The nature of the growth of the gardenia is such that the soil becomes full of roots which appear at the surface, evidently in search of air, thus precluding the stirring of the soil. The tips of the rootlets were club-like in form and the other exposed parts of the root systems showed further nodules which were found to be caused by nematodes.

The house foreman was conducting a series of tests with various fertilizing materials to control the trouble, but with no apparent success.

In response to his plea, an experiment was outlined for the next season. It seemed from the inspection that the cause of the yellow condition of the foliage might be due to the texture of the soil. Another contingent factor might have been a question of fertilization. The experiment was planned to include soils of various textures, with various amounts of a readily available nitrogenous fertilizer. In addition, a distinctly acid soil was also used.

DESCRIPTION OF SOILS.

The leaf mold used was a very coarse material. It was taken from a swampy place and consisted of leaves in various stages of decomposition, fibrous roots, and small twigs. There was very little clay in it. This material had a water-holding capacity of about 90 per cent, but it was so coarse and open that even with this high water-holding capacity good aeration was possible. This material was used on plots 1 and 7.

Plots 2 and 8 had two inches of leaf mold in the bottom of the bench in which the young plants were placed. After benching, three inches of sphagnum moss were added.

The red shale used was the Penn loam common in Central New Jersey and Pennsylvania. It is a rather heavy soil containing a large percentage of silt. The soil used was alfalfa sod and reacted alkaline. This soil was used for two mixtures. Plots 3 and 9 received red shale with 50 per cent "humus" and plots 5 and 11 received red shale with 20 per cent composted cow manure.

The "humus" used in plots 3 and 9 was a commercial form of ground "humus." The 50 per cent mixture had a water-holding capacity of about 90 per cent. Previous work with this material had shown that it lacks capillarity. The water-holding capacity of this mixture is misleading, however, as a large part of the water does not seem to be available for the use of the plant. Being finely ground, this "humus" mixed with the red shale will not prevent the soil from settling. When first placed in the bench it is open, but later seems to settle.

The mixture of red shale with 20 per cent composted manure had a water-holding capacity of about 62 per cent.

The sandy loam soil used was from a meadow that had not been cultivated for about eight years, and was so poor that nothing much grew upon it except brambles. It was distinctly acid in reaction. The soil had a water-holding capacity of 52 per cent, while the addition of 20 per cent composted manure increased this to 56 per cent. The clay loam soil secured from the grower had a water-holding capacity of about 65 per cent.

OUTLINE OF THE EXPERIMENT.

A bench in one of the rose houses was selected for the experiment and this was divided into fourteen plots each about 3 feet 4 inches long by 4 feet wide.

There were two series of six plots of the soils mentioned above: Leafmold, leafmold and moss, red shale with 50 per cent "humus," clay loam, red shale with 20 per cent compost, and sandy loam with 20 per cent compost. The first series, plots 1 to 6, inclusive, were to receive a semi-monthly application of 100 grams of high grade tankage; and the second series, plots 7 to 12, inclusive, 50 grams. Plots 13 and 14 were to receive 75 grams of tankage semi-monthly. Plot 13 was sandy loam with 20 per cent compost, plot 14 was sandy loam, which was distinctly acid and received 2000 grams of ground limestone, which would be at the rate of about 6 tons to the acre.

The plan may be seen by referring to table No. 1.

CONDUCT OF THE EXPERIMENT.

The plants used were secured from the grower previously mentioned. These were benched on June 7, 1915, being planted 12 inches by 16 inches, twelve plants to the plot. Six of these were from 3-inch pots and six from 5-inch pots. At the time the plants were benched, there was a slight yellowing of the foliage on all and it was noted that the roots of all were infested with the nodules caused by nematodes.

Fertilizer applications began August 3 and were continued every two weeks until April 14, except the December 1 application, which was omitted.

MEASUREMENT OF GROWTH.

Measurements were made of the height of the plants on July 7, one month after planting, on August 7, and on September 25. The plot averages are shown in table No. 1.

The measurement of July shows the leafmold plots to have the best growth. Sandy loam with 20 per cent compost ranks second and shale with 20 per cent compost third. The moss plots are lower. The poorest plots are the shale with 50 per cent "humus," with the clay soil a little better.

TABLE No. 1.

AVERAGE HEIGHT OF GARDENIA PLANTS AT DIFFERENT STAGES OF GROWTH.

Soil	Plot	Feed	Average Growth, Inches			Height of Average Plant April 14
			July 7	Aug. 7	Sept. 25	
Lear mold	1	High	9.00	14.70	25.60	
	7	Low	9.58	14.04	24.54	34.5
Moss	2	High	7.88	13.00	23.58	
	8	Low	7.96	12.08	22.75	37
Shale plus 50 per cent "humus"	3	High	6.67	7.75	10.91*	
	9	Low	7.23	8.50	10.63	14
Clay loam	4	High	7.56	10.96	18.63	
	10	Low	7.44	11.25	18.13	22
Shale plus 20 per cent compost ..	5	High	8.00	12.69	22.00	
	11	Low	9.10	13.79	23.71	30
Sandy loam plus 20 per cent compost	6	High	8.93	14.15	24.04	
	12	Low	8.83	13.47	24.17	32
Sandy loam plus 20 per cent compost	13	Medium	9.10	13.69	23.96	
Sandy loam plus 2000 grams lime	14	Medium	7.42	12.04	23.25	

* Four plants dead.

The measurements made August 7 show the same relative ranking as on July 7, but the "humus" plots have fallen behind. September 25 found a general increase in growth, the moss plots taking second place, but the "humus" plots have fallen considerably behind and four plants have died on plot 3. These plots continued to decline. By October 15, plot 3 had lost five plants and plot 9 had lost six. At the time the plants were removed from the plots on April 14, plot 9 had lost ten of the original twelve plants.

The leafmold, moss and sandy loam plot (6 and 12) maintained a vigorous growth throughout the whole season; the foliage being the glossy, dark green color desired. As the season advanced, the shale with 20 per cent compost plots (5 and 11) became slightly discolored as to foliage, but the growth on these plots continued

vigorous, however. The clay loam plots (4 and 10) grew very slowly and remained discolored throughout the entire season.

Plot 13 (sandy loam with 20 per cent compost) gave a good free growth with glossy dark foliage throughout the season. Plot 14 (sandy loam with 2000 grams ground limestone) produced fairly free growth, but it was slender and there was some discoloration of the foliage.

YIELD IN FLOWERS.

The monthly yield in flowers for each plot together with the total yield and the number in each grade is shown in table No. 2.

TABLE NO. 2.

TOTAL YIELD OF FLOWERS AND NUMBER IN EACH GRADE.

Total Yield of Flowers														
Soil	Plot	Feed									Grades			
			Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	Total	S.	F.	X	1
Leaf mold	1	High	...	...	...	3	...	...	1	4	3	1	...	...
	7	Low	...	...	...	5	11	8	6	30	13	10	3	4
Moss	2	High	...	...	2	26	5	4	11	48	25	9	7	7
	8	Low	...	1	...	12	22	21	20	76	19	28	19	10
Shale plus 50 per cent "hu- mus"	3	High	1	3	8	14	4	3	5	38	1	3	24	10
	9	Low	...	3	8	6	15	...	1	33	3	5	21	4
Clay loam	4	High	1	1	...	...	...	...	3	5	...	1	1	3
	10	Low	2	3	1	...	5	12	18	41	3	9	9	20
Shale plus 20 per cent com- post	5	High	...	...	1	11	4	...	...	16	8	3	5	...
	11	Low	1	...	...	13	71	22	8	115	59	37	11	8
Sandy loam plus 20 per cent compost	6	High	...	...	4	19	13	1	6	43	18	13	10	2
	12	Low	...	...	1	22	72	37	16	148	85	31	25	7
Sandy loam plus 20 per cent compost	13	Medium	1	1	...	18	61	32	24	137	66	35	17	19
Sandy loam plus 2000 grams lime	14	"	1	...	...	1	45	24	1	72	38	27	6	1
Totals			7	12	25	150	328	164	120	806	341	212	158	95

The system of grading is as follows:

Flowers having stems over 12 inches.....	Special (S)
“ “ “ between 10 and 12 inches... Fancy (F)	
“ “ “ “ 7 “ 9 “ ...Extra (X)	
“ “ “ “ 4 “ 6 “ ...No. 1 (1)	
“ “ “ “ 3 “ 4 “ ...No. 2 (2)	

It will be noted that those plots which received the lighter application of nitrogenous fertilizer gave a greater total yield than the high-fed plots in the case of every soil mixture except the “humus.” When you consider, however, that the low-fed “humus” plot (No. 9) lost nearly all of its plants before the end of the season, this mixture may be disregarded in that comparison.

The greatest total number of blooms was recorded as cut from two sandy loam with compost plots (Plots 12 and 13). The next highest was from the shale with 20 per cent compost (Plot 11). The clay loam plots (4 and 10) did not bear many flowers until the very end of the season, and the blooms were nearly all No. 1. The growth on these plots, it will be noted, was somewhat restricted.

The two treatments that made the best growth were among the lowest in yield; viz., the leafmold and moss plots. Since the value of most flowers lies in the length of the stem, the quality of the blooms being equal, these plots should have shown to better advantage. However, the probabilities are that with a different method of bud selection, much larger yields would have been secured from these plots.

At the close of the season, an average plant was lifted from each treatment and measured and photographed. Another plant was lifted and the soil very carefully washed from the roots in order to determine the amount of nematode infestation. It will be recalled that all the plants had nodules when benched.

The heights of these plants are shown in table No. 1. It will be noted that the moss plot has taken first place in the measurement of growth, leafmold having fallen to second place. The other treatments rank the same as shown by the measurements made September 25.

It was found that the primary roots in all cases had a twisted, gnarled appearance, this being due to the nematodes in the roots at the time of benching. A considerable amount of variation was found in the secondary root systems.

The plant taken from the leafmold had a very vigorous growth and a large growth of fine roots, but only a few nodules were found on the tips of the rootlets. The plant grown in moss had a great root system that almost entirely filled the moss. As in the previous case, a few nodules were found on the ends of the rootlets. When the dwarf plant from the “humus” plot was examined, it was found that the roots resembled bunches of grapes, so thick were the nodules. The clay loam plot produced a plant that had a “hard” condition of growth and was partly defoliated. The root system

was fairly good, but a considerable number of root-nodules were found. The plant from the shale and compost plot was vigorous and covered with buds, but was slightly discolored as to foliage. The root system was good, but there was a number of nodules, though not nearly so many as in the clay loam. A few nodules were found on the plant taken from the sandy loam with compost, but the root system was very vigorous.

The conclusions drawn from these data seem to point to the nematodes as one of the factors in the yellowing of the foliage of gardenias. On open, porous soil mixtures the plants seemed to out-grow the original infestation of nematodes, although no reason for this can be given. The lime added to the soil did not seem to benefit the plants.

NEMATODE AND LIME STUDIES.

Since the conclusion was drawn at the close of the season of 1915-16 that nematodes were one of the causative agents of "yellowing" in gardenias, an experiment was planned for the season of 1916-17 to test their potency in causing this trouble. Two types of soil mixtures were used, sandy loam with 20 per cent composted manure, and red shale composted with 25 per cent manure. In order also to study further the effect of lime upon the growth of the plants, various amounts of ground limestone were used upon some of the plots.

TABLE NO. 3.

AVERAGE HEIGHT OF GARDENIAS AS AFFECTED BY LIME AND NEMATODES.

December 12, 1916.

Soil	Ground Limestone	No Nematodes		Nematodes	
		Plot	Average Height, Inches	Plot	Average Height, Inches
Sandy loam and 20 per cent compost	4000 grams	1	30.42	.....	.....
Sandy loam and 20 per cent compost	2000 grams	4	30.91	8	25.11
Sandy loam and 20 per cent compost	none	5	33.19	9	24.39
Shale and 25 per cent compost ...	2000 grams	2	31.25	6	26.73
Shale and 25 per cent compost ...	none	3	30.59	7	28.42

The same bench was used as in the previous experiment. All soil was removed, and the bench was scraped and sprayed with formaldehyde and also with lime-sulphur 1 to 9. Fresh soils were used without sterilization.

The bench was divided into nine plots each about four feet wide by five feet long. An outline of the treatment is shown in table No. 3. The limestone applications would amount to 5 tons per acre in the case of the 2000 grams per plot application.

Plots 6 to 9, inclusive, were inoculated with nematodes by spreading over the surface of each plot a quantity of pieces of roots containing nodules. Plot 6 was separated from plot 5 by a cement partition.

The plants used in the experiment were propagated in our own houses, and at the time benched were of a fine color and the roots were apparently free from the nodules of nematodes. These were benched the latter part of June.

The plants on these plots were measured on December 12, and the average height of the plants in each plot is shown in table No. 3.

While the differences in growth are not so marked as in the previous year, there is sufficient evidence to substantiate the preference of this plant for an acid soil and for an open soil. The best plot is the no lime plot of the sandy loam soil, plot 5. The appearance of this plot is the best also. The foliage on plots 1, 2 and 3 (sandy loam with 4000 grams of lime and the shale plots) is beginning to lighten in color on the growing tips.

The plants on the plots inoculated with nematodes are slender, not free growing and are not so tall as those on plots not inoculated. In addition, the foliage is scanty and began to turn yellow in the latter part of September. On plot 9 (sandy loam, no lime) the roots of the plants are covered with nodules and the older leaves are becoming mottled and are beginning to drop. Plot 6 (shale, with lime) is the poorest plot. The leaves are nearly all yellow and have the brown areas much like burning in the margin.

On December 26, the foliage on a few plants on plot 1 (sandy loam, 4000 grams lime), plot 2 (shale with 2000 lime), plot 3 (shale, no lime) had become rather yellow. The roots of some of the plants were examined and apparently no nodules were present. The exposed root-tips, however, were dead, markedly so on plots 1 and 2.

The conclusions that may be drawn from these two experiments are: (1) That the gardenia prefers a light, open soil texture rather than clay and other compact soil types. (2) The gardenia does not like lime, it succeeds on a soil that is slightly acid and had done well on a noticeably acid soil. The effect of the lime seems to be to restrict root action by possibly causing in some way the killing of the tips. (3) The presence of nematodes in the soil with the resultant root nodules is detrimental to the gardenia. Where nematodes occur, the plants are checked in growth and the leaves mottle and fall.

In the first year's experiment, the presence of the nematodes and the marked difference in their effect upon the different soil types

confused results as to the effect of the different soils. Why the nematodes should thrive in a compact soil and not thrive in the leaf-mold and moss, we are unable to say.

Yellowing of the foliage of gardenias may be caused by anything that will restrict or injure the root growth. Among factors that cause this are a compact soil, lime, and nematodes.

WHAT SCIENCE HAS DONE AND WILL DO FOR FLORICULTURE.

By E. A. WHITE, *Cornell University, Ithaca, N. Y.*

In this age of intense specialization in all horticultural practices it may be well to review some of the scientific factors which have played and are now playing such an important part in the development of ornamental plant production.

In the earlier periods of agricultural education the term *horticulture* covered a wide range of subjects. In many agricultural colleges the horticulturist was expected to teach forestry, landscape gardening, plant breeding, pomology, vegetable gardening and floriculture. In some cases he was also expected to teach botany, entomology and other sciences. In fact, it was expected the instructor would be capable of teaching all subjects which pertained in any way to plant life. Not only was he expected to teach these subjects, but much of his time was required for the administration of the business of his department, also for research and for what we have come to know as extension teaching.

This field was altogether too broad for the ordinary man to master, although certain horticulturists did make a marked success, even when handicapped by the requirements of such a broad field of duties. The scope of the work was nevertheless too varied for the best results.

The last decade has witnessed a decided change in all lines of agricultural teaching. What was formerly designated as agriculture in the curricula of land-grant colleges, has been sub-divided into dairy industry, animal industry, poultry raising, farm crops, and subjects of a like nature, until there is now no distinct course in general agriculture given in some agricultural colleges.

The same trend toward specialization has been noticeable in horticultural subjects, and the old idea of horticulture has been merged in the development of special departments, such as landscape gardening, fruit-growing, flower-growing, forestry, vegetable gardening, and the like. This is an age of specialization, and the administrators of agricultural colleges have come to appreciate the fact that no individual can teach satisfactorily a wide range of subjects, requiring such intensive application, as to those dealing with special phases of animal and plant life.

In the earlier periods of horticultural teaching, major attention was given to fruit culture, some emphasis was laid on landscape gardening and vegetable culture, but little attention was given to instruction in flower growing. A few agricultural colleges had

ranges of glass where some flowering plants were grown, but these were largely plants of botanical interest rather than of commercial importance. About ten years ago a Department of Floriculture was organized at the Massachusetts Agricultural College and distinct courses in commercial flower growing were offered. A little later, courses in flower growing were developed at the University of Illinois. So far as can be learned, these were the first attempts in this country to train men in a broad way in distinctly scientific aspects of the subject. Since that time, courses in floriculture have been introduced into the curricula of many agricultural colleges, and much investigational work along flower-growing lines has been undertaken. In the larger number of instances, however, this work is still intimately connected with other branches of horticulture, and the work is being done by men interested in other subjects.

The application of scientific principles to floriculture is, therefore, of comparatively recent date. The flower-growing business, however, is an old one. In the early days of American flower production, commercial growers of flowering plants recognized the need of but few scientific principles. The greater number of these florists received their training abroad, and the apprentice system through which this was obtained, taught *methods* rather than *principles*. These men learned to grow plants and to know under what conditions they attained their best development, but they knew little of the reasons for their successes and failures. During the last decade, conditions have changed in a marked degree. The demand for rare flowers of better quality has steadily increased, and with this demand there has come a keener competition. This competition and the demand for better products have made it necessary for present-day leaders in the flower-producing industry to call on science for every assistance possible, so that there should be better methods of production and these at the least possible expense. The margin of profit in the flower business is not a broad one.

In the earlier periods of work in teaching floriculture, the writer met with but little encouragement from men engaged in the business. Their opinion of the courses at the agricultural colleges was often expressed in terms far from complimentary. Within recent years the horizon has broadened and many men who at first ridiculed the teaching of floriculture in agricultural colleges have so completely changed their opinion that they are now not only eager that their sons should take work in these institutions, but they are offering most cordial co-operation in every way possible. To illustrate this point I would like to quote from a recent editorial in "Horticulture" entitled, "We're Getting There."

"The trend of interest in the experiment stations and state and national horticultural institutions generally is undoubtedly making towards a larger recognition of and a fuller co-operation with the floricultural or ornamental departments of horticulture. Ithaca, Amherst, Urbana and other educational centers have been wheeling into line and each year sees

advancement in the desire and in the ability to serve the floricultural interests in a practical and acceptable manner. It has been said that whatever is of permanent value is usually of slow growth. We have long watched this little cloud like a man's hand. Its growth has been exasperatingly slow, but it is big now with the promise of the recognition to be accorded to ornamental horticulture as second to none among the many excellent and reputable commercial activities to which a young man may wisely turn in choosing his life work."

And again, from an editorial in the "Florists' Exchange" for November 4, 1916:

"The letter that we publish in this issue from Cornell, recording where the students of the Floricultural Department have gone in the last year or two and the situations they now occupy, is of much interest to all of us.

"The young men and women who have had the great advantage of the scientific education that the well-equipped American colleges give, go forth as the agents of science. No one who closely observes passing events can have failed to see the large influence for good that college-trained men, and others who have been similarly trained even if not in colleges, have exerted. Consciously or unconsciously, the facts obtained by the students from those whose days are passed in research work—the scientists—are brought down into daily practical application. This is one of the colleges.

"The man who has been trained purely as a 'practical man' and has no theoretical or scientific learning, is ill-balanced. While such a man will probably be successful nine times out of ten as against the purely theoretical student who may attempt to run a greenhouse establishment, yet we all know that a combination of the well-grounded practitioner who has been also trained scientifically, is the ideal.

"That science and organized learning are invaluable is well recognized by many of our leading commercial florists, who are sending their sons to the various universities. It is unnecessary to mention names; these facts are known widely.

"The colleges do not turn out mere theorists; the kind of students they develop is of the well-balanced type. It is not the fault of the teaching system if they are not. Here they learn something, at least, of the secrets of plant physiology, as well as the botanical kinship of plants, and their general

make-up and uses. Geographical botany might be pursued further, even at the colleges, with advantage. Chemistry, physics, knowledge of insect life, how to combat destructive insects and diseases, land measurement, principles of greenhouse building and heating, accounting, and the many business parts of a man's training and education, are among the subjects instilled at the colleges.

"Moreover, do not omit to take into account the splendid social intercourse at a highly susceptible period of a young man's or woman's life, by being brought daily into contact with others of similar age at these seminaries. Here a spirit of emulation is begotten, and habits of industry and of love of books and study are engendered that must affect all their after life and character.

"Each of us wishes our profession and industry to advance. This can best be assured by the increased intelligence of the individual members of it, by the liberality of their theoretical and practical training in all that affects the skillful raising of plants, their cultivation and the disposal of them for the sustenance or amelioration of the lives of the people."

The field truly has broadened during the period in which floricultural instruction has been given in the United States.

But we should review rather briefly the relation which the various sciences bear to methods of present-day flower and plant production. Botany in its various branches probably touches the subject most closely, for in plant growing under the somewhat artificial conditions in greenhouses an application of the principles which govern healthy reproduction and growth in plants is constantly necessary. However, before we have plants, we must have soil, and the application of chemistry to the soil is doubtless as important as is botany.

The flower-growing business in the United States is important. In New York State it is especially so. The last census states that the value of the production of flowers and plants in this state approximates five million dollars. This is approached by no other state. The total annual production for the United States was valued at thirty-four and one-half millions. This was an increase of eighty-five per cent during the last decade.

In the early history of plants and our study of plant nomenclature such names as Theophrastus, Pliny, Linnaeus and others stand out prominently, and we must not forget that scientific floriculture as it is practiced today owes much to these men.

During the earlier periods of ornamental plant culture, valuable work was done through scientific expeditions to foreign countries, piloted by experienced plant collectors who were for the most part systematic botanists. These men brought back many species es-

pecially suited not alone for growth under glass, but in the open as well. Most of these earlier scientific collecting expeditions were from England, Germany and France, but the species of plants collected were sooner or later brought to America, and our conservatory collectors were thus enriched. The painstaking work of Cesalpino, Linnaeus, Jussier, Gärtner, and others in the classification of plants has been of inestimable value to present-day plant growers, for through a knowledge of the habitat and relationship of plants, we have gained valuable information of their cultural requirements such as soil, temperature, light and moisture.

In the early part of the nineteenth century many collecting expeditions were piloted by such systematic botanists as Sir William Hooker, Sir Joseph Banks, and others; and the species of plants from both tropical and temperate sections which were found suited for growing under glass in this country were increased manyfold. In later years, the work of these men was followed by many others, among whom were Sir Harry Veitch, Verschaffelt, Engelmann, Victor Lemoine and the Vilmorins. The scientific work of Dr. Torrey, Asa Gray, and other systematic botanists has been of great value to floriculture, for many of the species of native plants they listed are now valuable garden species. Through the work of these men, therefore, our list of ornamental plants has been increased by introduced species from the flora of every part of the globe.

While some of these plant collectors have been practical horticulturists, they have been so educated that they have been enabled to conduct scientific experiments. They have learned to associate *practice* with *scientific truth*. Among such men who have been engaged in the work in recent years no name stands out more prominently than that of Jackson Dawson. While Mr. Dawson's early education and training were largely of a practical character, his natural instinct enabled him to do work of a strictly scientific nature. The results of his propagation of material sent him by plant collectors and his breeding of hardy roses have been unusual. His introduction of the Dawson Rose, W. C. Egan, Farquhar, and Sargent roses, have been valuable acquisitions in the floricultural list of species. His "passing on" is a distinct loss to the horticultural world.

A scientific collector of note in recent years is E. H. Wilson, the student of Japanese and Chinese species, whose work for the Arnold Arboretum at Forest Hills, Massachusetts, is bringing to our American flower lovers such ornamental species of value as *Lilium myrophyllum*, *Lilium Sargentiae*, *Hydranges Sargentiana*, *Clematis montana* var. *rubens*, *Buddleia variabilis* var. *superba*, *Syringa Wilsonii*, and many others. The history of the work of these collectors and a study of their introduction of ornamental plants is extremely interesting, but space will not permit a detailed discussion of these.

Following the introduction of species of plants from foreign countries and the somewhat unnatural conditions under which it became necessary to grow them, the plant culturist began to realize

the need of a thorough knowledge of the requirements of different plants as regards light, moisture and heat. Slowly but surely present-day floriculturists are coming to realize that they must have a better knowledge of plant structure and physiological processes in plant life before they can successfully grow plants.

That division of botany which we know as plant physiology and which relates to the vital function of the plant, is, then, of the greatest importance to the grower of ornamental plants under glass or in the open. Not only has the scientist learned many plant secrets in this respect during the last decade, but he has been able to instruct the practical grower regarding these and to demonstrate that certain environmental factors, such as heat, light, and many others, so change and modify plant tissue that improvement in plants may be marked.

The results of the wonderful investigations of Hofmeister, Green, De Candolle and von Mohl in morphology; of Robert Brown, Schleiden, Malpighi and Nageli in vegetable anatomy; of Koelreuter, Sprengel, Major and many others in plant physiology, have taught and are now teaching plant growers the principles which underlie cultural practices.

A thorough knowledge of the science of botany is, therefore, necessary for the successful cultivation of ornamental plants either under glass or in the open, and the gradual development of this field through scientific investigation and research is constantly revealing new truths which closely affect plant growth.

Vegetable pathology has an intimate relation to the healthfulness of plant tissue. Study in this science by such men as De Barry, Wakker, Tubeuf, Unger, Hallier and others, has revealed the character of many plant parasites, and these men have given suggestions for exterminating and avoiding them. Probably the most valuable suggestions which have come from scientific plant pathologists in recent years are those which have shown practical growers the importance of proper sanitary conditions in greenhouses if a healthy and vigorous growth is to be maintained. Since the pathologists have shown carnation growers that stem rot is induced by deep and careless planting, and that rose mildew is the result of sudden and pronounced atmospheric changes, there has been as marked a decrease in these diseases as if special directions for their eradication had been given.

It has been necessary for men of science to demonstrate to practical flower growers that proper environmental surroundings are as essential for healthy plants as they are for human individuals in the home. In an excellent paper before the New York Federation of Floral Clubs during Farmers' Week, Professor E. O. Fippin considered the relationship of sanitary conditions in the soil to healthy plant growth. In this paper Professor Fippin states:

"It should always be known that the crop produced is competing with many other plants in the soil. We well recognize the importance of keeping down weeds which will compete with the main plant for food

and moisture; but we have not given so much attention to the competition of the crop with the microscopic plants in the soil, the bacteria and the fungi. Instead of being a dead mass, the soil is teeming with life. In every grain of soil there may be millions of bacteria and many kinds of fungi and molds. These require the same food elements that the higher plants use, and it may frequently happen that the soil conditions are as well or perhaps a little better suited to the development of these microscopic plants, as to our higher plants, and they may gain the ascendancy and utilize the plant food designed for the crop.

"This idea, too, is one of the recent developments in soil fertility. In England, Russell and Hutchinson have developed many facts showing that in their soil, and especially in soils known to be sewer-sick, and in greenhouse soils that have come into a so-called sick condition, there may be the development of excessive numbers of the very simplest animals, protozoa, which compete with the plant roots and with beneficial forms of bacteria. They have developed facts which indicate that any treatment which kills or reduces the number of these competing organisms tends to promote the growth of higher plants, and in general to create a better state of fertility. It should be pointed out that in the greenhouses, where conditions are continually favorable for their growth, such difficulties may become more acute than in the field where the variations in climatic conditions and the changes in season, including freezing in winter, tend to hold such processes in check."

During the earlier periods of plant culture, the dealers in novelties were dependant on material introduced from foreign countries. These plants are still interesting many dealers. Within recent years, however, native haunts of ornamental plants have been so thoroughly gone over by the collectors that there are now fewer new species of value. Since this is true, plant growers and the introducers of novelties have come to lay marked emphasis on the study of genetics and this somewhat new subject has influenced the character of plant products to a marked degree. This influence has, however, been more pronounced in the changes of special characters because of changed environmental conditions, so that new varieties have interested our plant culturists. While some work in scientific plant breeding was done by Linnaeus, Koelreuter in the latter part of the eighteenth century laid the first real foundation of our scientific knowledge of the subject. Later, such names as Knight, Gärtner, Darwin, Focke, De Vries, Mendel, Bateson and others stand out prominently in scientific literature relating to plant breeding.

In their recent book on this subject, Bailey and Gilbert state as follows:

"One of the 'signs of the times' in North America is the attention that is being given to practical breeding of cultivated plants. Until within a comparatively few years, however, breeding work has been unscientific in the extreme. Much of this has been because there have been few scientific principles which were tangible. Scientific experimenters are rapidly accumulating results with many kinds of plants, and eventually there will probably be formulated definite statements as to how to proceed to secure desired results. However, there is no hope that plant breeding can ever produce forthwith the things that we desire, in the way in which the mechanic devises new machines, notwithstanding all the suggestions or persons who write with much self-assurance. For all that we can now see, plant breeding will always be an experimental process."

It is then for men of science to formulate, through experimentation, the laws which govern heredity in plants so that practical growers may apply these in so far as possible in bringing out new and improved varieties.

Present-day scientific breeders of plants are, therefore, not now working to produce new varieties so much as they are to discover, if possible, the laws which govern hereditary characters. Definite color and form inheritance which may be expected by crossing different plants, is of far more importance to the scientific mind than is the production of some commercial variety of plant which excels those now in existence.

As has been stated, next to botany in its various divisions, probably no branch of science has been more beneficial to floriculture than chemistry. Botany and chemistry are so interwoven in plant culture that it is impossible to state the relative importance of each. The application of chemical principles touches many phases of plant life closely. Both organic and inorganic substances must be studied; air, moisture and the soil elements which make life possible, are all intimately bound up in chemical substances.

A study of the atmosphere in its relation to plant life, and of the soil in its relation to vigorous plant growth brings us closely into the chemical world. In earlier horticultural practice, little attention was paid to atmospheric conditions. The air as a source of plant food was unthought of, for the plant growers of that early period had little to aid them in solving their problems regarding the source of material for improving the growth of their plants.

For years there was a realization that the nature of the soil was important for healthy growth, but only within comparatively recent times has there come to be a realization that the atmosphere is equally important. Outdoor atmospheric conditions are little sub-

ject to control, but in greenhouses the plants' environment in this respect may be more easily governed. With the discovery that a large percentage of a plant's substance was carbon, and that the plant received this carbon from the air, there came to be a better appreciation by plant growers of the fact that plants are as dependant on a liberal supply of fresh air as is man. The greenhouse builder, therefore, began to consider the principles of ventilation, and although present-day methods of greenhouse ventilation are extremely crude, nevertheless plant growth under glass is much more healthy than in the earlier days when it was thought that all that was necessary was to give the plants warmth and light. Consequently, the early greenhouses were small and sunken in the soil so as to retain all the heat, and every possible effort was made to prevent the escape of warm air from the greenhouses and to let little fresh cool air in. Consequently the plants became so susceptible to fungous diseases that it was almost impossible to grow many species. When the scientist showed the culturist the value of fresh air, there was an improvement in the quality of the plants grown. Larger, airy houses were built and these were located on more exposed elevations where good air circulation could be obtained and larger supplies of fresh air were given the interior of the houses.

The plant grower, however, is more concerned with soil and fertility questions than with almost any other problem in science. He grows a wide range of plant species, each with its own requirements, not only with the chemical constituents of the soil, but with the physical character of the soil as well. It is generally known that plants under glass grow best if the soil contains a mixture of medium sand, silt and clay. The proportion of these varies with different crops, and all species' requirements have to be studied carefully. They are learned largely by investigation and experimentation. Experiment stations in connection with the agricultural colleges and the United States Department of Agriculture have done much valuable scientific work in determining correct conditions for various species of plants, yet much remains to be learned.

Probably no cultivated plant is more particular regarding proper physical and chemical constituents of the soil than is the rose. The best commercial rose growers in America today are those men who have kept closely in touch with the scientific work of the experiment stations.

The chemist, especially the agricultural chemist, is rendering valuable assistance to the flower grower. Unfortunately he is handicapped to a certain degree and his limitations will not always permit him to fulfill the expectations of practical men. Only a few days ago the writer received a sample of soil with the request that it be analyzed and the sender informed as to what he should apply to make it a good soil for violets. Many men fail to realize that all mineral elements must be rendered soluble before they can be used by plants, and that organic substances must exist in correct combination before they are of value to plants. A soil may contain a quantity of food elements and yet the plant may starve. For this

reason chemical analysis is seldom satisfactory from the grower's viewpoint. The chemist can determine the minerals which comprise the soil, but he is not familiar with the food requirements of plants of different species and the availability for these plants of the minerals and organic substances in the soil. This is a problem to be determined only by experimentation for each particular crop and for each type of soil, and it is the function of the scientists in our experiment stations to work out these problems for the benefit of the practical grower.

The chemist is, however, teaching the flower grower the sources of plant food and how to treat his crops so they will receive the proper amounts of nutrition. The chemist is also giving the flower grower a better knowledge of the so-called "commercial fertilizers" and their effect on plant growth.

It is impossible to discuss fully all that scientific chemistry has done for floriculture. The results of this type of work have been so far-reaching, not only as regards a plant's environment with reference to atmosphere, soil, and its fertility, but along the lines of insecticides and fungicides as well. We know that sanitary conditions in the home have much to do with keeping disease germs and insect pests from gaining a foothold; nevertheless contagion sometimes spreads from less careful individuals in the human family. The same principles apply with plants, especially in greenhouses. The scientific chemists have solved many a complex problem for the florist in the eradication of both insects and fungi on plants.

In this work the chemist has been assisted in a considerable degree by the entomologist and the plant pathologist. The work of the entomologist has been to study the character and the life history of different groups of insects injurious to plant life, and through this intimate knowledge to aid the chemist in compiling formulas of sufficient strength to exterminate the pest. As certain chemical substances are injurious to plant tissue, the scientific work of the plant physiologist has also been necessary to bring about methods of insect extermination by the use of chemical substances which are effective and which are in no way detrimental to the vigor of growth of plants.

A question has sometimes arisen in various departments of agricultural colleges regarding the value of a knowledge of physics. One of the fundamentals of plant growth is light intensity, and I consider physics a most important subject for all students of floriculture. The science of physics has been of great value to the florist, but it might be much more so if some enthusiastic student would perform his experiments on light intensities in greenhouses and demonstrate the influence of different light intensities on different types of plant growth. We know in nature that there are many species of plants which are light demanding; others are shade enduring and even shade demanding. We usually consider that it is necessary that greenhouse plants obtain all the sunlight possible. This is, in general, true for most plants, but others demand some shade. The percentage of light under which plants make their best

development is still a matter of conjecture. The physics of light, however, has been studied, and science has demonstrated the possibility of building greenhouses with the pitch of the roof at such an angle that the maximum amount of sunlight will be available.

In Ithaca and in some other sections of the United States, there is a low percentage of sunlight, especially during December, January and February. It is important for the flower grower that his plants get all the sunlight possible during these months. No branch of science will probably ever make possible the manufacture of artificial light equal in value to that from the sun. It therefore devolves on the student of physics to tell us how to so construct our glasshouses that the plants may obtain the maximum amount of light during such time as sunlight is available. In glasshouse construction, wood is an undesirable factor from many viewpoints. It quickly decays under the moist atmospheric conditions, and the necessity of using large dimensions in order to secure strength, makes it detrimental to light intensities; yet thus far it has been found impossible to eliminate it from the construction of glasshouses because of the expansion and contraction of metal due to the influence of varying degrees of heat. This breaks the glass.

It is, therefore, desirable to eliminate as much wood as possible from the construction and to use the smallest dimensions for sash-bars and supports. Recently, very small wooden sash-bars have come into general favor with glasshouse builders; wooden posts for interior supports have been eliminated, and a system of supporting the roof by various trusses is much in favor. Greenhouse builders are, therefore, depending on students of physics to demonstrate to them the supporting power of trusses for different sized roofs, so that the rigidity of the greenhouses may be increased. Upon this rigidity depends in a large measure the value of the greenhouse, for where there is considerable vibration there is a consequent breakage of glass.

It is impossible to properly demonstrate in a single article all that science has done and will do in the future to develop the art of flower and plant production. As has been stated, the necessity for an application of scientific principles to floriculture has been of comparatively recent origin. As competition increases in the world of flower production, there is sure to be a greater demand for scientific information, and the field of investigation is broad. There is a constantly increasing demand for men in the flower-producing industry who have had broad scientific training. These men are to become in the future America's foremost flower producers.

THURSDAY, DECEMBER 28, 2:00 P. M.

**THE BEARING OF SOME BIOLOGICAL FACTS ON BUD
VARIATION.**

By E. M. EAST, *Harvard University, Cambridge, Mass.*

(Note:—This address will be published in the *American Naturalist* in the early part of 1917. The Secretary was unable to learn at what date it will appear.)

***THE INHERITANCE AND PERMANENCE OF CLONAL VARIETIES.**

By M. J. DORSEY, *Experiment Station, St. Paul, Minn.*

Since the life of every plant is limited, in some cases being terminated by seasonal influences and in others enduring for a period of time fairly characteristic of the species, it follows that forms of today have been derived from those pre-existing. Reproduction, then, in some manner in which independently existing parts are produced, must be exercised continually by each species in order that it may persist. The methods of reproduction are classified generally under two very inclusive heads—vegetative and sexual. The multitude of special structures of flower, stem, or root, characteristic of each family or genus, by means of which reproduction is accomplished, does not invalidate the above classification.

There are fundamental differences between vegetative and sexual reproduction, although the same plant may be reproduced by both methods and either may be sufficient for the persistence of the species. The former is much simpler and consists broadly in setting apart a portion of a single parental individual. In sexual reproduction a new plant unit arises from the fusion and growth of two special sex cells and one or two parent plants may be involved. In vegetative reproduction the parent plant is multiplied quantitatively. In sexual reproduction there is a mechanism for a complicated interchange of separate hereditary units or factors. This introduces into the life cycle of the plant a process which makes it possible for the offspring to inherit from both parents and to be different from each other.

The fact that these two methods of reproduction are reversible and interchangeable is of special interest in horticulture, where economic fruit-bearing plants are dealt with. Sexual reproduction is resorted to in originating horticultural varieties, and in the nursery vegetative or asexual reproduction is used in propagating or multiplying them.

Vegetative reproduction produces groups of individuals, varying in number, which are very closely related genetically and which are, for the most part, quite similar in external appearance. Webber ('03) proposed the term "clone" to apply to such groups and to include those which are "propagated by the use of any form of vegetative parts, such as bulbs, tubers, cuttings, grafts, buds, etc., and which are simply parts of the same individual seedling." Shull ('12) has suggested an extension of the meaning of the term to include a "group of individuals traceable through asexual reproduction (including parthenogenesis when unaccompanied by genotypic segregation) to a single ancestral zygote, or else perpetually asexual." An extension of the meaning of clone does not hinder its application in the original sense and will furnish a term applicable to both plant and animal forms. In fruit clones, as the apple or plum, a cutting or scion — the unit of reproduction — is traceable to a single ancestral zygote, and sexual fusion does not occur between individuals. The unit of growth is different from a unicellular form in that it consists of a portion of the parent individual composed of a group of cells variously differentiated. In the clones where sexuality exists, asexual propagation prolongs the sporophytic interval many times beyond the normal life of the individual concerned. In the case of the potato, propagated asexually through the tuber, a plant is interposed between the different tuber generations.

Through the human agency, vegetative reproduction is extended to forms and also by methods, as budding and grafting, not found in nature. The human agency has also been a means of extending the range of species by an extension of the cultivation of clonal varieties. Long association of man with plants capable of producing edible fruit has resulted in the selection or isolation of varieties which, in practically all cases, differ in some character from the usual types of the wild parent species. This same process of selection by association has continued with varieties after the start has once been made from the wild forms. Darwin in his classic treatise on "Plants and Animals under Domestication," lays special emphasis upon the influence of the human agency in modifying types.

While by vegetative means we are able to isolate and maintain varieties in a commercial sense, nevertheless it is essential in nearly all cases where the edible portion is developed from the flower, to also maintain sexuality to ensure fruitfulness. Sexuality, then, is for the most part retained in fruit clones even in those cases where vegetative reproduction does not follow the natural method and has been extended artificially. On the other hand, the taking on of sexuality by plants has not changed the independent relation between somatic growth units.

The clone varies in its relation to its species. It may carry or represent only a part of the characters of the species to which it belongs. In our fruit varieties, especially in those of species where large numbers are involved, classification is rendered difficult because of such minute differences. Taken as a whole, however, a

complete analysis or list of the characters of all of the varieties of a species would undoubtedly give a complete genetic expression of the species in question, since each clone represents a different zygotic combination, and is generally heterozygous for a large number of characters.

The Origin of Varieties: In the following table most of the important varieties of the apple, cherry, grape, and plum known to American horticulture are classified with respect to what is known of their parentage. This table is based upon the historical accounts of the different varieties of fruits as given in the monographs published by the New York Agricultural Experiment Station (Beach '03; Hedrick, et al., '08, '11 and '15; Hedrick and Wellington '12).

TABLE I.

PRESENTING DATA AS TO THE PARENTAGE OR ORIGIN OF THE IMPORTANT VARIETIES OF THE APPLE, CHERRY, GRAPE, AND PLUM.

	Both Parents Known.	One Parent Known.	Neither Parent Known.	Origin as Sports.	Total.
Apple	3	39	588	4	634
Cherry	20	61	1,064	0	1,145
Grape	74	57	72	0	203
Plum*	49	108	524	1	682
	146	265	2,248	5	2,664

It will be seen from table I that commercial varieties of fruits have arisen in four ways: (a) from controlled crosses where both parents are recorded, (b) from open pollinated seed where only the seed parent is known, (c) random selection from the wild, or from seedlings of accidental or native origin where neither parent is certainly known, and (d) as bud or somatic variations. By far the larger number of varieties, including many of the most important ones, have been random selections. Numbers, however, should not be confused with commercial importance. Most of the important American varieties are of native origin, but many foreign species are represented. In the case of the grape a larger number of important commercial varieties have arisen as a result of controlled crosses by breeders than with any of the other fruits listed. While there are numerous references to bud sports in horticultural literature, as yet these sports have not been an important source of new varieties in any of the fruits named. However, in floriculture many more of the important commercial varieties have originated in this manner. Bailey ('95) estimates the number of named horticultural varieties in America which have arisen as bud-variations at two

* The writer is indebted to Mr. W. D. Valleau for assistance in tabulating the data for the plum.

hundred. Carrieria, in 1865, gave a descriptive list of one hundred and fifty-four horticultural varieties of importance in France which had arisen as bud variations. (Bailey '95.)

Thus it will be seen that most of our fruit varieties are germinal rather than somatic in origin. As a means of obtaining new individuals, however, sexuality and vegetative propagation differ fundamentally. In horticultural practice vegetative propagation is an expedient method of obtaining new individuals on account of the heterozygous condition of our "improved" varieties. The extent to which it is practiced raises some questions as to the nature and extent of variations in clonal varieties.

VARIATION IN CLONAL VARIETIES.

Differences between individuals in a clone can be accounted for in two ways: (a) Those due to the interaction of environmental factors — fluctuations, and (b) Those of a genetic nature arising from the somatic tissue subsequent to gametic fusion.

Fluctuations: The term fluctuation is used in this connection in the usual evolutionary sense, as applying to the non-inheritable variations arising by means of the adjustment of an organism to its environment. There is now a tendency, however, by some writers to hold that some fluctuations are in part inherited. In fruit varieties there are two distinct types of environmental variations: (a) The individual and local variations, or fluctuations, and (b) Regional variations, broader in extent and well illustrated by marked differences in certain varieties of apples grown in districts of the eastern part of this country compared with those grown in the western part.

All fruit characters are subject to fluctuations, and varieties are judged commercially according to their response to the factors of the environment, or "limiting factors." The essential principle of fluctuations in fruit varieties is expressed in the law of optimum. Emphasis has been placed by Stewart ('10-'11) upon the application of this law to nutrition studies and by Young ('14) to regional and character variations. Stated briefly, the law of the optimum means that for the highest development of a given variety there must be present the optimum environmental conditions for the most desirable expression of tree and fruit characters.

The complexity of variations in fruit will be evident when we consider that soil, atmospheric conditions, stock, and season may all be variable, as are also plant functions under different states of the environment. The difficulty of isolating a single factor of any of these has been recognized in cultural experiments and most statements regarding adaptation have been based upon a mass action of all the factors involved, or the state of balance between the limiting factors.

Somatic Variation: Discontinuous somatic variations are different and distinct from fluctuations, although they may be in part obscured by them. They have been recognized for a long time, although differently interpreted from the standpoint of evolution.

The terms used to apply to sudden or marked variations have differed considerably. Darwin used "bud variation" to include "all those sudden changes in structure or appearance which occasionally occur in full-grown plants in their flower-buds or leaf-buds" (Darwin '90). "Sport" is used in the same sense and also in connection with striking variations in seedlings. "Single variation" was also used by Darwin. Webber ('09) used "clonal" or "bud variation" and "bud segregation." De Vries ('09) says that bud variations "should rather be called," "vegetative mutations." Again De Vries, writing on spontaneous changes, illustrates them by bud variations. MacDougal, Vail, and Shull ('07) use "vegetative mutations" or "bud sports." East ('08 a), Emerson ('15), and Stout ('15) use "bud variation." Stout ('15) also uses "sporadic variations" in discussing dwarf forms. Emerson ('15) discusses the relation of bud sports in maize to somatic segregation or mutation. Morgan and his associates use mutation in the sense of factor changes. Clausen and Goodspeed ('16) use the term "factor mutation." In his work with *Diffugia* Jennings uses "uniparental inheritance." Bud variation, however, using bud in the botanical sense, as applied to discontinuous changes in clones, has some limitations when used in connection with unicellular forms. Somatic variation, as distinct from germinal, is a suitable general term to apply to all discontinuous variations arising in somatic tissue.

Somatic variations have been classified from many different points of view; the usual classifications with respect to inheritance recognize three classes: (a) those which are completely inherited, (b) those partially inherited, and (c) those which are not inherited. Classified again with respect to the time of occurrence in the life cycle they are of two kinds, (a) somatic, and (b) germinal. Again they have been classified as (a) continuous, and (b) discontinuous.

Type and Range of Discontinuous Variations: In 1890 Darwin brought together an extensive summary of somatic variations affecting fruit, leaf, and flower in many different ways and emphasized their wide occurrence, both in the wild and under domestication. In the two volumes of the Mutation Theory, De Vries ('09) discusses at length the types of discontinuous or sudden variations. Instances are cited of atavistic characters appearing by bud variations as in *Antirrhinum* and *Appalotaxus*. "Sectorial variability" in flowers due to the segregation of color is described in a number of horticultural varieties. Other types of variation, such as color change and variegation, are treated in detail. The work of these two writers is outstanding in the literature of this subject. De Vries, however, ascribed greater evolutionary significance to discontinuous somatic variations than did Darwin.

East ('08 a) points out that there have been primarily three types of bud variations recorded: Variations in color (which constitute about 70 per cent), cut-leaved variations, and those due to the loss of a "prickly, hairy or felted condition."

In ornamentals, bud variations have long been recognized as a source of new varieties by gardeners and florists. Among the newer carnations which have arisen as bud variations may be mentioned Victor, Chicago, White Lawson, White Enchantress, Rose Pink Enchantress, and Enchantress Supreme.*

A deepening or change in color in fruits, is of frequent occurrence. Powell ('98) records a case of deepening in color in Gravenstein. Beach ('05) describes a similar variation, which he named Collamer, from Twenty Ounce. In this case both color and size were affected. Another bud variation of a deeper color and of independent origin was named the Hitchings (Beach '10). Kraus ('16) found one branch of a Bartlett pear which bore fruit that "had prominent yellow stripes from calyx to stem." The bark was also affected, being striped "golden yellow," "green and brown." Besides a deepening of color complete color differences arise as bud variations. The yellow Magnum Bonum plum produced a branch which bore red fruit (Knight cited by Darwin ('90). Green grapes arise from deeper colored varieties, as blue (Powell '98) or purple (Darwin '90).

Variations resulting in greater size, some of which might be termed "giants," are often met with in fruits. Paddock ('96) describes a large-fruited Concord. Two large-fruited variations from this variety have come to the attention of the writer, one, exceptionally large, was found by F. E. Gladwin at Fredonia, New York, and another, the Gillette sport, by S. A. Beach at Penn Yan, New York. Self-pollinated seedlings from the latter showed that the large size was inherited in part.† In 1882 the Isabella grape produced several sports bearing black grapes "immense in size and exceedingly sweet and delicious" (Powell '98). These variations, apparently quite similar, were named Pierce by the California Horticultural Society, and have propagated true under a wide range of growth conditions.

Gates has shown that in *Oenothera gigas* the individual cells are increased in size and that in some way in this mutant the chromosome number has become doubled. It would be interesting to know if instances of such marked increase in size like those mentioned in the grape could be accounted for on the same basis. Possibly in some "critical division" size factors for berry were not fractionated and a "double dose" is present.

Bud variations affecting leaves are numerous and for the most part are color changes, either variegated or solid, and changes in shape—the cut-leaved types. Stout ('15) presents an excellent summary of these, and describes extensive pedigree tests of *Coleus* clones, studying especially color pattern and variegation. Types arose in these extremely variable forms both by bud variations and fluctuations, in considerable numbers, although the proportion of bud variations varied much in all the clones studied.

* Personal correspondence with A. J. F. Baur.

† Personal correspondence with S. A. Beach, Ames, Iowa.

A dominant chemical change occurred in *Oenothera rubricalyx* which is inherited as a Mendelian character. Gates ('15) suggests in this case it is only necessary to assume that a single chromosome or portion of one underwent a chemical change.

A bud variation on an atavistic mutant from *O. cruciata* which returned to the parent type is mentioned by De Vries ('03). Reversions are also occasionally found in the moss rose in which the affected parts are destitute of moss.

An illustration of a bud variation in which pubescence was involved has been the production of nectarines from peaches, some of which reproduce through the seed. Darwin ('90) cites several instances where nectarines arise from peaches either through the seed or by bud sports. One instance is mentioned, the reverse of the above, where a "nectarine tree yielded peaches by bud variation." Evidently the relation between the peach and nectarine is very close and unstable, since trees have been known to "indifferently" (Darwin '90) bear peaches and nectarines and in rare instances both comprise sections of the same fruit.

The time of maturity in fruits may be affected as a result of somatic variations. As an instance of this, two branches of the Mountain Rose peach may be mentioned which ripened a week or ten days earlier than the normal variety (Powell '98). This difference in season was reproduced by bud propagation. A shift of the ripening season in the other direction occurred on one branch of the May Duke cherry which bore fruit ripening later and more oblong in shape than the typical cherry (Knight cited by Darwin '90).

Growers know of many variations in fruits which have never been reported in the literature. Changes in color, russetting, stem length, and obliqueness are variations observed. As an instance of an unrecorded variation known and discussed locally by growers, may be mentioned the Bardwell apple, which is a highly colored Oldenburg growing in the orchard of W. Bardwell at Excelsior, Minnesota. The history of this variation is not certain, as it came with a lot of Oldenburg bought from a local nursery. If it is a seedling, it differs but little from the Oldenburg except in color. If it is grafted, it in all probability is a bud variation.

Weeping forms are known in a large number of trees and are grown widely as ornamentals. Darwin ('90) cites a number of instances where seedlings were grown from weeping forms, as in the oak, ash, peach, beech, and birch. Mention is made of the fact that many of these reproduce the weeping habit completely in only a part of the seedlings, although some, as the oak and birch, all come true from seed. The weeping habit is lost in some cases and in others it does not appear until some growth has taken place—10 to 15 years in seedlings from *Betula alba*.

Dwarf forms, which have appeared suddenly, or in some cases with intermediate steps, have been recorded in a large number of species. Summaries of these can be found in several places. Keeble and Pellew ('10) and others have studied the inheritance of the dwarf sweet pea with the normal, tall, or bush forms. The F_2 of

semi-dwarf crosses, gave tall, semi-dwarf, and dwarf forms. The F_2 of the cross between "Cupid" and bush produced tall, bush, and two types of "Cupid." Bartlett ('15) describes an intermediate and a dwarf form which occurred in a culture of *Oenothera Reynoldsii*. In *Hibiscus*, Stout ('15) found a dwarf which appeared as a "sporadic variation" in a pedigree culture. "It differed from the robust form in possessing a smaller stature, shorter internodes, smaller leaves, many crinkled leaves and in the development of lateral branches from the base of the main stem." East and Hayes ('11) report various types of abnormalities appearing in maize, including dwarf, bifurcated, and branched ears.

Digby ('12) reports the appearance in 1905 of "a single pin-eyed flower" on *Primula Kewensis* which normally bears flowers of the thrum-eyed type which are self-sterile. "This flower was fertilized with the pollen of a thrum-eyed flower and good seed were set," which germinated and produced plants which "bore both pin-eyed and thrum-eyed flowers and were fertile." The whole stock of the fertile *P. kewensis* came from this single flower.

Pritchard ('16) reports a change in sex in the dimorphic hemp plant, as a result of the removal of flowers, injections of different chemicals, and shading by bagging. Hemp is typically dioecious, but as a result of manipulations, primarily the removal of parts, both the pistillate and staminate plants produced the other sex.

Stout ('13) describes a bud variation in a *Pelargonium* chimera, due to a "mechanical rearrangement of the kinds of cells already present." In this case it seems to be clear that there is a segregation of the white and green cells, the white bearing no chlorophyll, but, as Baur has shown, colorless plastids are present.

East ('10b) working with the potato, found five variations involving a loss of color, two changes from long to round in shape, and four from shallow eyes to deep ones. These variations reproduced true.

White ('13) tested the inheritance of fasciation in tobacco and found that it gave a 3:1 ratio in the F_2 with the normal character, showing the sport to be different from the normal form in a single factor.

Bailey ('95) cites an instance of "sexless evolution" in the Chilean strawberry which in two years "departed from its wild type so widely as to be indistinguishable from the common garden strawberry."

In the above partial review of some of the types of discontinuous variations which have been observed and commented upon, it will be seen that many are striking and that a wide range of characters is affected in this way. Instances of some of those which are of significance from the standpoint of the fruit clone primarily, have been included. For a more extensive presentation, the reader is referred to the works of Darwin ('90), De Vries ('09), Cramer ('07), East ('8b-'10b), Stout ('15) and others. It should be kept in mind that the question is one of clonal permanence, or the type and range of changes taking place in a genetic combination already

made, since in the clone vegetative propagation is supposed merely to continue or perpetuate gametic combinations. As noted above the variations mentioned are readily observable and in some cases even striking. Their occurrence is unquestioned, and they are of sufficient frequency to warrant careful consideration as factors in varietal permanence, especially since according to our present nursery methods, little attention is given to them. Too much emphasis, however, should not be placed upon the striking observable somatic variations in this connection. As is indicated by some of the later researches, there may be and undoubtedly are, minor and less evident changes which occur somatically in fruit clones which will be revealed by closer study.

CLONAL PERMANENCE.

The substratum: A brief summary of some of the possible and actual internal relations of the chromatin elements is presented here in order to suggest some of the conditions in which somatic variations may have their origin. The double or duplicate nature of the chromatin elements in somatic tissue presents many important features in connection with vegetatively propagated clones.

Table II. The substratum or genotypic complex in which variations have their origin; the normal condition in a cross being the basis of comparison.

From Table II it will be seen that there are theoretical states of equilibrium in the internal relations of plants which may be of influence in clonal permanence. Somatic variations occur for the most part in fruit clones in an abnormal substratum. It is unnecessary to assume, however, that somatic variations from clonal types occur only under these conditions.

In the gametes which unite to form a new individual the potential characters, as we know them in the mature plants, are represented in some manner. The peculiar life forces exhibited in the union and growth of the sex cells bring together hereditary elements, which, upon development, result in both normal and abnormal characters. From the evidence presented in known hybrids it appears that factors can be brought together in the zygote which cannot gain complete expression as growth and differentiation proceed, but which affect some functions, primarily reproductive. Mendelian studies, as well as those of somatic variations, have centered largely around observable characters. Little is known of the total number of factors, characters, or units which go to make up the complete individual. This being true, it would seem that the relation of the chromatin elements, as they must of necessity exist in the somatic tissue, can only be determined in part by the external character expression.

The following combinations selected from Table II will serve to illustrate something of the extremes possible in crosses: Growth usually vigorous, chromosome number doubled, flowers and fruit of

	Normal.	Abnormal or Extreme.
Species Relation	Mono-or-intra-specific.	Interspecific.
Plant Growth	Normal for the species and adapted to its range.	Weak, normal, or unusually vigorous. Adapted or not.
Reproduction	Gametes unite readily.	Gametes unite readily or rarely unite. Attraction between them may be weak. Growth may stop at different periods.
Chromosome Number	Equal and homologous. Chromatin elements "congenial."	Equal or unequal and unhomologous. Uncongenial.
Sterility or Fertility	Self-fertile, self-sterile, cross-fertile, and cross-sterile.	Mostly sterile, pollen aborted in varying degrees. Either pollen or egg suppressed in part or completely, removing the individual from the reproductive tract or hereditary stream.
Character Expression	Homozygous or that of the dominant characters irrespective of parents.	Arrested or from both parents, intermediate, or almost completely resembling one parent.
Stability of Character Relations	Character relations stable. Propagate uniformly vegetatively. Characters homozygous or heterozygous.	Heterozygous. Mutations and somatic variations.
Sap— Composition	Same from both gametes	May differ in the parents in density or composition.
Flower	Parts developed normally.	Parts suppressed completely or in part, sometimes normal and functional. Parts sometimes increased in number or of extreme size.
Fruit	Normal for the species in size, color, etc.	Of abnormal size, color or form. Extreme for the species in many respects.
Seeds	Produced normally and viable.	Viable or not viable.

extreme size, plant sterile. Again we may have an interspecific hybrid, weak in growth, pollen mostly aborted, and fruit seldom developed. Other combinations suggest themselves with part of the characters normal and part abnormal or extreme.

It will be evident to those familiar with fruits that many varieties are characterized by extreme character combinations or extreme development of characters. They have been selected for the most part for this reason. A number of extremes may be propagated vegetatively, provided they are not of such a nature as to be actually prohibitive. Being extreme in many characters, clonal changes are more likely to be toward the mean, and away from the extreme. This is the general idea involved in "degeneracy" and "running out." "Gametic contamination" (Hoshino '15 and Castle '16) may possibly be a factor modifying character expression in a clone, if this influence is not permanent for long periods under asexual reproduction.

Where extreme characters are carried forward asexually almost indefinitely in clones, the exact influence of an intimate association of the hereditary factors upon each other during the long clonal somatic generations can only be conjectured. Emphasis is placed upon this extreme condition of the substratum or "reaction-system relation" (Clausen and Goodspeed '16) from the standpoint of clonal permanence through asexual propagation. Owing to the extremes brought together in crosses the nature or composition of the two germplasms may be agencies affecting clonal permanence, especially where long periods of time are involved.

Cytological Nature of Somatic Variations: Many facts are contributed by cytology, which go far toward giving a clear conception of the nature of heredity and the course of the germplasm. Some, especially those dealing with irregularities, are included here in order to see how far cytology furnishes a basis for an understanding of those internal changes resulting in somatic variations.

Among some of the contributions outstanding, may be mentioned cell division in relation to genetic continuity, a constant and characteristic chromosome number, reduction division, gametic fusion, individuality of the chromosome and the relation between segregation and reduction division. The evidence also of a constant arrangement or position of the chromosomes in succeeding cell divisions is convincing and is being extended. Forms such as *Ascaris*, *Lychnis*, *Crepis*, *Drosera*, in which shape or size differences occur in the chromosomes, present the most important contributions on this point. Furthermore the relation between sex and the accessory chromosome, and linkage and "cross-over inheritance," are instances where the results of cytology and genetics agree and are mutually confirmatory. Cytological studies of a large number of widely separated species have in fact revealed the general occurrence of many of the phenomena of the cell.

In connection with a discussion of the clone, where a long series of cell divisions occur, the presence of certain comparable stages in

somatic and reproductive divisions is significant. Aside from the formation of the chromosomes, their pairing or separation, there is a time in both divisions when the chromosomes are drawn to the equatorial plate. The formation of daughter nuclei requires that the chromosomes, whether heterotypically or homeotypically divided, be pulled to the poles. During these progressive stages, it has been generally recognized that there would be a chance for irregularity in one or more of the many details which may affect a part of a chromosome, a whole one, or more than one. The alternative to irregularity is a perfect completion of the process in a normal manner in all divisions. It should be remembered, however, that in either case we are dealing with the same chromatin and the same hereditary factors. If the state of balance during reproductive divisions is more delicate or complicated than in the somatic divisions it should again be restored to the normal condition in the zygote and its cell derivatives.

The physiological individuality of the chromosome is shown at reduction division where in normal cases there seems to be an independent action between them which permits of a new alinement or arrangement from that previously existing. The alternative to this independent behavior would be a greater attraction, in part or in whole, between the chromosomes as they originally associated in the gametes of either sex. If each chromosome were not free to act independently and a greater attraction existed between those from a particular gamete than between homologous chromosomes of the other gamete, normal chance Mendelian ratios would not occur and varying degrees of correlation would result. In the case of the sex chromosome we have one of the best illustrations of physiological individuality and also one of the most certain instances of a definite relation between a character and a chromosome. The work of Morgan and his associates has shown that definite groups of characters are borne by particular chromosomes which are linked together in inheritance. The physiological differences between chromosomes and parts of chromosomes is interesting in this connection, in that this conception furnishes a basis for explaining the local or restricted influence of irregularities in somatic divisions since only those factors carried by the particular chromatin in question would be affected.

It would be interesting to know how pairing takes place between allelomorphs in cases where an unequal number of chromosomes are brought together in the gamete. For instance, if factors A and B are represented in the same chromosome of one gamete and in different chromosomes of another, will the pairing be determined on the basis of the chromosome or of the allelomorph? There may be several possibilities in such a combination with respect to the factor representation in the chromosome. The chromosomes, for instance, may be double in number in one parent, as in the cross *Drosera longifolia* (20x) and *D. rotundifolia* (10x) (Rosenberg '06) or they may differ in number by one or more. Another possi-

bility would be, in the pairing of chromosomes, that the two bearing factors A and B would pair within the single chromosome bearing A and B, or if only single chromosomes pair, the two bearing A and B may pair alternatively by chance, with the one bearing A and B. If there cannot be a complete pairing of allelomorphs when the chromosomes are not homologous, a variable progeny would be expected. Some abnormal ratios may in part be explained on this basis.

Chromatin extrusions from the nucleus into the cytoplasm have also been observed by a number of writers. The significance of this phenomenon from the standpoint of the factors concerned is not certain. While most instances of this have been observed in the germ cells it is quite probable that it is not limited to them, especially in extreme crosses. It would seem that the characters carried in the particular chromatin affected would be lost as far as descent was concerned. There is a suggestion in the phenomenon of a cytological basis for "running out." Montgomery concluded from his studies of *Hemiptera* that certain chromosomes are in the process of degeneration and disappearance and he suggests the connection of these changes with running out and regressive mutation. A study of the chromosome behavior in the horticultural varieties may show irregularities in chromatin distribution associated with instability.

Without reference to stable or instable varieties, what is the status of cell descent as it must of necessity take place? There are many horticultural varieties of great age. In fact some date back so far in their origin that their history is uncertain, and the original variety is confused with seedlings from it or with closely related types. In other words, since the original gametic fusion took place in a particular variety, centuries may have passed, and a derivative of the original individual may have followed the course of human migration into various countries and climates, subjecting different individuals of the clone in this way to a wide range of environmental factors. This has been mentioned under regional variations. Assuming a cell in a plum or an apple twig to be 50μ in length, there would be 500 per inch. If a tree makes an average growth of one foot a year there would be in lineal descent 6,000 cells produced annually. In a clonal variety two hundred years old, at the same rate of growth, there would be 1,200,000 cells in lineal descent from the original zygote. Some clones are older than this and some grow faster. These statements apply only to lineal descent and do not include an estimate of the number of divisions which must occur laterally or lineally, starting perhaps from thousands of other individuals within the clone. Here cell division is subjected to extremely severe tests and it would appear that the hereditary material brought together in the first clonal zygote must be capable of almost indefinite fractionation—the clone being carried forward asexually far beyond the normal life of its individuals. The condition here as to cell descent is comparable to the unicellular forms

except that in the higher plants organization and differentiation enter in.

In this connection, however, as to gaining or losing a character two interpretations can be given; (a) from the standpoint of the individual and (b) from the standpoint of the species. It would seem that a character could be considered as "gained" if it is new to the species and "lost" when it disappears from all the individuals of a species. Atavistic characters may in part prevent a rigid application of the term.

One of the most interesting and important points brought out in the critical study of *Oenothera* is that of "parallel mutation." Stout ('15) found that in the same color pattern in *Colerus*, the same types of variation arise independently, either in the same or successive generations. Also two plants identical in appearance and coming from adjacent branches on the same plant "gave different progenies in successive generations."

Irregular chromosome behavior has been summarized by Gates ('15) and East ('15). The observed changes have included tripling, doubling, and an increase in number by one or more chromosomes. Likewise a decrease in chromosome number has been reported. Besides changes which affect the whole chromosomes, those affecting only a part of one occur, as is shown by the work of Morgan and his associates.

The chromosome number may be influenced in different ways, as by an error at reduction division, an extra division longitudinally of one or more, or by a transverse division of one or more. A transverse and longitudinal division would result in a different factor distribution in the increased number. Differences in chromosome size may be regarded as an intermediate stage in a transverse division of the chromosome. Attempts to explain mutations have, as Gates ('15) states, been grouped around the idea of (1) redistribution of Mendelian characters, (2) loss of factors, and (3) reduplication of gametes. In all of these, however, the idea prevails of the loss or recombination of existing qualities. Gates also classified types of germinal changes as morphological and chemical.

In discussing this phase of the subject an attempt has been made to review briefly some of the outstanding facts concerning the departures from normal chromatin continuity which have been observed, and which are of significance in connection with the problem of clonal permanence, and also to emphasize the status of descent, especially in the fruit clone. While most of the observed changes have been studied in germinal cells, nevertheless it should be remembered that these are the beginnings of the clone, where sex exists, as in the fruit varieties. The important point is that irregularities in chromatin continuity do occur, regardless of where, in the life cycle. Cytological studies show the continuity of the chromatin from cell to cell, so that it is quite probable that irregularities in chromatin distribution will produce similar results, in a given form, wherever they occur. In the clone, descent as well as

growth takes place as a result of cell division, and it appears that nowhere is this life process subjected to severer tests than in the fruit clone; especially where long periods of time and an abnormal substratum are involved. The question now arises as to whether the parallel relation between chromosome behavior and character expression which has been emphasized in connection with seed progeny obtains in the clone.

Genetic Nature of Somatic Changes: It should be stated here that the similarity between the characters which appear as somatic variations and Mendelian characters in seminal progeny, has occurred to a large number of observers of hereditary phenomena. This view has been expressed by Darwin ('90), Bailey ('95), Webber ('09), De Vries ('09), East ('15), Bateson and Punnett ('05), Morgan and his associates ('15), and others.

Darwin treats in some detail those cases of bud variation in hybrids which show a segregation of parental characters, and concludes from the facts presented that there can be no doubt that in an individual "hybrid" or "mongrel" plant there is sometimes a "return to both parent forms in leaves, flowers, and fruit, either wholly or by segments." De Vries ('09) holds that there are numerous cases of bud variations which are without doubt the splitting of hybrids. Bateson and Punnett ('05, p. 129) make the following statement: "There are many examples of differentiation between somatic organs manifesting itself in bud sports where the differentiating pairs of characters are such that we elsewhere know to be of an allelomorphic pair."

In discussing the nature of variations, Jennings ('16) says that "there is no change so slight that it might not be chemical in nature. In the immense organic molecule, with its thousands of groups, a simple transfer of one atom, one ion, perhaps, one electron, is a chemical change, and perhaps therefore discontinuous, even though its effect is below our perception with the most refined instruments." Bateson ('13) says that "the case of the double stock in which the whole male side of the plant differs from the female side, as shown by Miss Saunders, shows almost conclusively that segregation may occur in somatic divisions." Again Bateson ('09) in discussing the nectarine and the peach states that "segregation of the allelomorph for hoariness must have taken place at somatic division." Tischler ('08), East and Hayes ('11), and others advanced the idea that bud sports in general were due to a segregation of factors in vegetative division. De Vries ('09, p. 197) says that "mutations follow one another so that the plant gradually becomes separated from the original form by an increasing number of characters." Again he says ('09, p. 649) that "progressive mutations are due to the formation of new pangens." Gates ('15) emphasizes the point that derivatives of a cell in which segregation of characters occurs would be the same regardless of what plant organs are affected. Emerson ('15) holds that "somatic mutants" are "fundamentally the same as seminal mutants." Furthermore,

"mutations must certainly result from the loss or gain or the modification of genetic factors. They must rise potentially whenever a change in genetic factors takes place, whether in the somatic cells or germ cells of the parent, or in the early somatic cells of the mutant offspring." (Emerson '13). A recessive allelomorph can make its appearance by a failure of the determiner for the dominant character to be fractionated in division. This has been pointed out by East ('08 a). If this process takes place in somatic tissue a character can gain expression in this way somatically whether derived from the male or female parent.

When once a discontinuous variation arises in a clone it persists, and, we may assume, is as permanent as the other clonal characters, although there seems to be no doubt that some characters, like some clones, are more permanent than others. It is quite probable also that there are many more abnormalities in division than would be indicated by observable somatic variations. Furthermore, in clones discontinuous variations may occur in many characters which cannot be detected externally. Under present methods of propagation in the nursery a somatic variation which will reproduce asexually may have a far-reaching influence in perpetuating a strain "off type."

Discontinuous variations have been classified with respect to the place in the life cycle of the plant in which they occur as somatic and germinal, the chief distinction being that in the case of the germinal change a given character is affected in all parts of the plant while in the case of the somatic change the influence may be local. This distinction, however, is only relative, since a change occurring soon after gametic fusion may be as far-reaching as germinal changes in that the whole plant may be affected.

Emerson ('13) points out that if a mutant appears in a seed progeny this fact does not necessarily prove it to be germinal in origin. In the fruit clone the "sport" may be limited to a single bud, branch, or fruit, or the entire plant individual may be a vegetative part of a sport.

The chromosome view of heredity has gained wide acceptance because of the way in which the facts of cytology and genetics fit together. Whatever future research has in store it seems at present that the evidence warrants placing considerable confidence in this view. If the determiners are carried by the chromosomes, as the later research indicates, this view becomes of particular interest in connection with the clone, since, as we have seen, growth and descent require almost indefinite division or fractionation of the chromatin. Irregular chromosome or chromatin distribution has been suggested by many writers as an explanation of discontinuous variations of the type mentioned above. The relation of the chromosomes to character expression has recently been a field of intensive investigation.

East ('15) reviews the evidence of the relationship between chromosome numbers and species complexity, and concludes that

there is none. The significance of the difference in chromosome number in closely related forms is not clear. The external character expression may be quite similiar except in homologous detail. While the total number of characters in two closely related species is doubtful, whether the number is the same in each or different, it would seem that there would be a different division or allotment of the characters or determiners in the chromosome as a result of a larger number in one form, unless the extra chromosomes are blanks or duplicates as far as carrying determiners is concerned.

The relation of the chromosome number to the improvement of the cultivated forms has also been emphasized by East ('15). His thesis is that the greater the number of chromosomes the greater the possible combinations and hence the greater the difficulty of improvement by securing desirable combinations. If the greater the chromosome number the greater the possible combinations of characters, it may follow that the plant with the larger possible character combinations would be capable of greater adaptability. It would be difficult, however, experimentally to check up adaptability from this standpoint because of the immense number of combinations possible with a relatively small number of chromosomes.

The effect of an increased number of chromosomes appears to vary in different species. In some cases cells and nuclei are increased in size and in others are not (East '15 and Gates '15). Mutation in *Oenothera* has been shown to closely parallel chromosome behavior.

Studies of germinal mutants in *Oenothera* have shown three general classes. These are summarized by Gates ('15) as follows: (1) mutants in which there is one extra chromosome, the *Lata* series, (2) those in which the chromosome number is double, the *Gigas* series, and (3) those having an intermediate number of chromosomes, twenty-one, or the *Semi-gigas* series. Gates suggests that the changes producing mutants are probably limited and that in one group mutations are of one kind and in another they may be different. He states further the idea that mutations "indicate where the line of weakness exists" in the germ plasm and that these determine the "direction" of the mutations.

Clausen and Goodspeed ('16) carry the analysis of hybrids further than a part of the characters and discuss the whole reaction-systems between *Nicotiana Tabacum* and *N. sylvestris*. Differences within the *Tabacum* group "apparently depend upon certain factor differences within a common reaction system" while when any one of the *Tabacum* varieties is crossed with *N. sylvestris*, "the F₁ hybrid very nearly or completely reproduces on a larger scale the characters of the particular *Tabacum* variety concerned in the hybrid."

Of all the more recent work in genetics, that in *Drosophila* by Morgan and his associates has gone farthest in showing the relation between characters and chromosomes. In this form there are four chromosome groups and four character groups inherited as a unit. One of the larger groups is sex-linked. One of the chromosome

pairs is extremely small, relatively, and to date one of the character groups is also small. The connection between the latter while not certain is suggestive. On the bases of breaks in the inheritance of the characters within each group the loci for different factors have been plotted serially in the chromosome. The experimental results show the same relation between the allelomorphs in the "cross over" as in the normal chromosome arrangement.

The trend of the experimental results in this field indicates strongly that comparable irregularities affecting the chromosomes produce similar results, regardless of whether they occur in somatic or germinal cells, so that in the clone a variation once arising would persist. There seems also in fruits to be parallel "sports" as in the large-fruited Concords or the nectarine and the peach. These would be expected on the basis of the chromosome view of heredity, since in the fruit variety the characters are brought together only once in the original zygote and similar chromatin changes could be expected.

The persistence of rudimentary plant structures may be looked upon as an evidence of the permanence of characters when once represented in the germ plasm. Such characters, however, are relative and variable and may be interpreted either way with reference to character permanence. It would be interesting to know the difference, if any, in the way a rudimentary structure is represented in the germ plasm compared with a normal or recently acquired character. There are, in fact, many instances in plants where different characters have evolved at a different rate. MacDougal, Vail and Shull ('07) state that phylogenetically new characters show greater variability statistically than do the older ones.

Recent studies of inheritance show several different multiple or plural determiners for characters. This condition has been found to occur for different characters in a large number of forms. The independent existence of more than one determiner, either of which is capable of producing a character, was discovered independently by Nilsson-Ehle ('09) in brown chaffed wheat, and by East ('10 b) for yellow endosperm color in maize. Since then this interpretation has been extended to ear length in rabbits (Lang '10), capsule form in *Bursa Bursa pastoris* (Shull '11 and '14), size characters (East '10 b, and Emerson and East '13), flower size (East '13), height in maize (East and Hayes '11), leaf number in *Nicotiana* (Hayes '13), stature in peas (Keeble and Pellew '10), hardness in wheat (Nilsson-Ehle '12), and color in *Antirrhinum* (Baur '10). This partial list is included to show something of the range and character of this type of inheritance.

It occurred to Shull ('11 and '14) that if there is more than one factor or determiner for a character these could be of two kinds, those alike and each one capable of independently producing a character — multiple factors or duplicate genes — and those which differ and collectively give complete expression of a given character — plural determiners. Shull holds that "the evidence for duplicate genes is adequate only for the presence of a ligula in oats, red pericarp-color in wheat, yellow endosperm-color in maize and the tri-

angular capsule-form in *Bursa*." Morgan and his associates have added other characters to this list in *Drosophila*. The exchange of the relative position of two chromosomes of "a longitudinal transfer of the capsule determiner from one chromosome to another adjacent," Shull shows, would result in the "duplication of the determiner for the triangular capsule."

In discussing the relation of a duplicate or an increased number of chromosomes to stability in character expression, East ('15) suggests that there is a great possibility for uniformity in chromosome duplication, since for a recessive change to appear it would be necessary to have "identical changes occur in two chromosomes." The writer wishes to extend this idea to include multiple and plural determiners, since a change affecting one of the several plural determiners necessary for the development of a character would cause a change in somatic expression of the character, while with the multiple determiners all would have to be affected in order to change somatic expression.

It will be seen from the discussion above that the trend of cytological and genetic research has been to come together; the research in each field amplifying that in the other. In the process of cell division there is a series of events handling the chromosomes as an entity, which can be interpreted as in agreement with what is now known of the behavior of characters in descent. Furthermore, the experimental results go further than to show that the chromosomes are the bearers of the factors, and place the loci of factors serially in order in the chromosome. If this view of heredity is correct, clonal permanence depends upon the constancy and uniformity with which cell division, in relation to descent, takes place. Irregularities in division affect character expression in so far as the factors concerned are affected. In the clone, reduction division does not occur in the line of descent so that segregation in the Mendelian sense does not take place, yet somatic changes are comparable to segregation at reduction division in that chromosomes and factors are affected. In fact the analysis of characters in somatic variations and in germinal progeny has involved largely the same ideas. It seems that this would be true, as in both the somatic and germinal tissue we are dealing with the same germ plasma and the same factors. Discontinuous somatic variations then, can be reduced to a genetic basis and it is from this standpoint that selection in clones will be discussed.

SELECTION WITHIN CLONES.

In horticultural literature mention has been made many times of differences between the individual plants of a variety. These differences are widely recognized by growers and nurserymen and their existence is not disputed. It has apparently occurred to a large number of observers that these differences could be isolated and propagated. This has led to the establishment of "pedigreed varieties." In this connection a few of the more recent attempts to im-

prove horticultural varieties, and the influence of selection in clones will be reviewed briefly.

The records of high and low yield in apples taken by different investigators (Beach '03; Macoun '05; Munson '05-'08) have been summarized by Stewart ('10-'11). Persistent differences, from year to year, between different trees of the same variety, were also found by Shaw ('14). Commenting upon experiments of this kind as well as statements from a number of correspondents, Stewart observes that the "rather scant evidence" of the value of selecting scions is negative. He emphasizes, however, the significance of the pure line or biotype concept in this connection.

Wright ('11) reports an attempt at bud selection in the York Imperial apple by the Tyson brothers in Adams County, Pennsylvania. About 1900 the Tyson brothers selected scions from two trees in their York Imperial orchard, which were striking on account of the uniformity of their fruit. They planted about 8,000 trees in a new orchard, all of the scions of which came from these two trees. At the time Wright made his report, these trees were just coming into bearing and he notes some striking variations in reference to the characteristic lop-sidedness in this variety coming from the same bud. Not only were there variations in the apples on the same tree, but there was a striking variation between the productiveness of the different trees so selected, and Wright states that "so far as the uniformity of fruit is concerned, the selection seems to have been absolutely without avail." Stewart,* after further observations of the same orchard, confirms the above conclusion, but also observes that an older tree when well loaded bears fruit "generally much less oblique" than a young tree.

Fraser ('13) has found differences in trees of apple varieties, in yield, keeping of the fruit, uniformity, and wood color. Certain trees of the Oldenburg produced larger and better trees in his nursery than others. Baldwin scions from the Auchter orchard, from one of the best trees as to fruit characters, produced "uniformly poorer growers than those propagated from several other individuals grown alongside." Hubbardston trees were found with a remarkable variation in the color of wood produced. Some of the best types of this variety have light-brown wood, but the experiments have not advanced far enough to correlate definitely the best types with wood color.

In the Washington Navel orange, Shamel ('15) found that worthless and undesirable types occur in greatest numbers in the younger trees—that is, farthest removed from the original tree. The inferior types are looked upon as an evidence of running out, and represent in some groves from twenty-five to seventy per cent of the bearing trees. The high percentage of inferior types is believed to be due to extensive propagation from vegetatively vigorous trees which are poor fruit producers, and represent one of the eleven different types of the Washington Navel, and also from a failure to

* Personal correspondence, J. P. Stewart, State College, Pa.

select buds from the best and most productive types. This work shows that there are unproductive limbs as well as inferior trees and the development of uniform groves requires both to be "worked over" or eliminated. Bud selection is regarded as a means of isolating the best types of the Washington Navel orange as well as conserving and perhaps improving the variety. If there are limbs of the best and typical trees of the variety which "sport" to inferior and unproductive types, obviously continuous selection will be necessary to keep the variety true to type or from running out. Shamel has also found striking differences with the peach.

Powell ('98) records an instance of variation in the Fay currant, in which 12,000 plants were produced asexually from the original purchase of 25. "The original bushes were uniform in size and heavy bearers." Among the 12,000 new plants propagated from them were types which were "tremendous bearers, others light bearers, while still others produced no fruit at all." In selection experiments with the blind and flowering wood of the rose, Corbett ('02) found no cumulative effect of selection in either and concludes "that the tendencies manifested in a branch are perpetuated" asexually.

With *Coleus*, Stout ('15) found that selection was effective in changing several characters to such an extent that he was able to establish varieties by selecting somatic variations. He concludes that "judging the variations in any one pattern by the range of bud variations that have thus far developed, it appears that any pattern tested in considerable numbers gives by bud variation the entire range of changes possible." Furthermore, when selfed seed progeny of *Coleus* were compared with clones the results "indicated only one of the patterns arose by fluctuating variations alone; that bud variations can give rise to as widely different forms as can be obtained among the various members of a hybrid progeny." It is interesting to note in *Coleus* that Stout considers "several of the principal types" to have arisen by "fluctuating variations."

Jennings ('16), working with *Diffugia*, studied the effects of selection in "uniparental descent" in a form admirably suited to such a study in that the characters observed were congenital and not influenced by the "growth stages and environmental modifications." Selection carried through a great number of generations showed that in this organism "the genotype is not constant, but changes by slow gradations, such as would not be revealed by imperfect selection for a few generations." Taking into consideration that the results in *Diffugia* differ from those in *Paramecium*, Jennings ('09) is "inclined to give much weight" to the difference between characters altered by growth and environment, and congenital characters. This paper is concluded with the statement that "in *Diffugia corona* a population consists of many hereditarily diverse stocks; and that a single stock, derived by fission from a single progenitor, gradually differentiates into such hereditarily diverse stocks; so that by selection marked results are produced." However, Jennings recognizes that we must not assume that the conditions are the same in all organisms and "it seems not improbable that in more complex

organisms the germinal material is more definitely localized, more completely protected from exterior influences, and manipulated in a more precise way, so that inheritance changes are less readily brought about."

Cole and Wright ('16) show that in bacteria the experimental results in selection can be interpreted as being in agreement with the pure line concept. They conclude, after a careful survey of the results of selection in bacteria that "the descendants of a single cell constitute a pure line, or, more strictly, clone, and on such material, although there is variation, selection is in no way effective unless actual hereditary mutations occur and are separated out."

It will be seen from the above review of the influence of selection within the clone that the results have been positive in some instances and negative in others. The difference undoubtedly lies with the material dealt with rather than with the method. The whole question involved in experiments of this kind is whether the selections dealt with differences which have a genetic basis or with fluctuations.

Eliminating the fluctuations from the discussion it would seem that clonal permanence can also be considered apart from the controversial question of the influence of selection in varying a character. From the genetic standpoint the question of clonal permanence then would be limited to those discontinuous somatic variations which, as we have good reason to believe, are due to character changes brought about by irregularities in cell division. From this standpoint selection within the clone would consist in isolating variations of a genetic nature after they had once originated. It may be, judging from the experiments of Stout with *Colceus*, that since some characters are believed to originate as fluctuations that a vegetative test of permanence is different genetically from a test of inheritance through sexual reproduction. The question to be kept in mind in dealing with discontinuous variations in the clone is (a) whether it is the character which is unstable, or (b) whether it is the character combination. Some caution should be exercised in making this distinction since the clonal type would be affected by either. As we have seen in the case of quantitative characters, somatic changes may involve multiple factors and the effect which would result from a change in a single factor would be one of degree. It would seem from the nature of the discontinuous variations observed in clones that the conception of the factor changes offers an adequate explanation.

In *Diffugia*, Jennings found that "a population consists of many hereditarily diverse stocks" and that these are *gradually* reproduced in a population from a single progenitor. Stout concludes from his work with *Colceus* that the same types could be isolated vegetatively as those which appear in a seed progeny. In the citrus also the types are very unstable. It would seem from the work of Stout that if the same types could be recognized in vegetative as in seed progeny, the characters are constant and that it is the character combination which is unstable. From the commercial stand-

point the value of bud selection experiments in an unstable form like *Citrus* would depend upon whether the selected type was as permanent as the original variety. Fruit varieties are selected because of some desirable commercial quality. Emphasis has already been placed on the extreme nature of many of these commercial characters. It should be remembered, however, that the desirable commercial characters in a clone have a genetic basis, and that types varying from this permanently are genetically different. A selected strain from this standpoint would be isolating or maintaining the original, and it is a question whether the original desirable commercial character can be obtained again from a less desirable or inferior type which has varied from it by means of selection.

The difficulty and uncertainty of detecting degenerate or inferior strains from fruit types is illustrated in the case of the Esopus (Spitzenburg) apple. Certain trees in an orchard of this variety "consistently produced small, ill-shaped, inferior apples" (Kraus '16). The limbs remaining after the tree was severely cut back for working over, bore the finest fruit in the orchard the following fall. Other trees of this type not so severely pruned produced the usual inferior fruit. From this and other observations it will be clear that as a point of entrance in selection experiments in fruit clones, especially the tree fruits, more attention should be given to an exchange of scions or buds from the good types to the poor types and vice versa in order to determine whether the difference between certain observed trees is largely or altogether a matter of environment. If two or more types respond similarly on the same stock they can be considered as fluctuations. It will be evident from a survey of the literature on bud selection that this precaution was seldom observed so that there was no certainty as to whether or not genetic differences were involved in selection experiments.

In a discussion dealing primarily with variations from the clonal type the impressions may be made that fruit varieties in general are very variable and unstable. Those who are familiar with the large blocks of many varieties of fruit propagated asexually in the nursery without particular attention to the selection of buds or scions and grown on a variable stock are impressed in the main by their uniformity. The writer does not wish to overlook this, yet it is important to recognize that there are differences and that as a result of our nursery methods variations relatively restricted in extent from source trees may have a wide influence. While there seems, undoubtedly, to be a difference in the permanence of different clones, this does not preclude the possibility of similar influences acting on each.

It would appear then that in the clone the conditions of descent are excellent for testing the permanence of the character since the element of sex with the possibility of recombinations is eliminated and cell division must of necessity fractionate the factors regardless of their nature or the structures which bear them. Furthermore, the element of foreign contamination is eliminated and a genetic combination once made is permanent except in those changes which occur in the course of descent and are discussed in this connection as discontinuous somatic variations.

OTHER FACTORS IN CLONAL PERMANENCE.

An influence of particular significance as modifying or affecting the permanence of the clone is that of "Senility" (Benedict '15) or "Senescence" (Child '16). Benedict based his work primarily upon young and old plants of the same species — *Vitis vulpina*. He used the size of the vein islets in plants of different ages within the species as a basis of measurement. His analysis indicates that the size of the vein islet is determined by some internal factor of the plants. They are largest in the young plant and show a progressive decrease coincident with age. The same facts were obtained in a number of other species. Other changes found to be correlated with age included a decrease in the rate of CO₂ production, a larger number of stomata but of smaller size, and a decrease in the imbibition of water by pulverized leaves. The changes discussed are believed to be due to "true senile degeneration" and not to external or internal factors "other than those produced in the meristematic tissue by age." A decrease in permeability is advanced as the most plausible explanation of the changes observed.

In reviewing this work Child ('16) points out that "cells which differentiate from meristematic tissue undoubtedly grow old much more rapidly than the meristematic tissue," and that the changes which result in a "decrease in size of the vein islet must be at most only the earliest stages of senescence." Child also expresses the opinion that decrease in permeability, while undoubtedly an important factor in senescence, may be looked upon as "merely the surface expression of changes in colloids or in the protoplasmic substratum." Moreover, the emphasis is placed upon the possibility that an apparently progressive change may in reality be made up of "many alternating periods or cycles." "There is evidence that in many cases the cell undergoes changes in the direction of senescence between divisions and in the direction of rejuvenescence at divisions."

Of particular interest are the preliminary investigations of Benedict in clonal varieties. Judging from the vein islets there is a progressive decrease in their size with age, in clonal individuals removed from the parent plant by many generations of asexual individuals. This held true with clones of different ages in the grape, pear, apple, plum, and peach. There is rejuvenescence, however, in seedlings as shown in the series Concord, Worden (a Concord seedling), and a Concord seedling. The rate of decrease was found to be most rapid in the shortest lived fruit, as the peach.

Benedict advances the opinion from these studies that our clones "must in time run out" and that rejuvenescence must be brought about by periodically resorting to new seedlings. "The general opinion among growers seems to be that those varieties which have been long propagated in this way (vegetatively) are showing decrease in yield and in resistance to disease."

No mention is made of a genetic change, in fact the implication is that there is none as a result of the "senile" changes. If a loss

of factors occurs with age in clones, progeny from the older and younger individuals would differ fundamentally in character expression, which should indicate which characters were lost. Van Mons (1765-1842) advanced the idea that the older varieties gave a seed progeny of less variability (Bailey '95). With the loss of certain factors combinations could occur in which there would be little or no rejuvenescence through crossing.

"Running out" seems to be a phrase which has persisted in horticulture. Running out and being replaced, or "going out of style" are different phenomena. Several factors enter into it. Undoubtedly one of the principal influences operating commercially is the competition of the older with the newer forms. Witness the "leaders" of the tree agent. Another consideration is mixing and substitution. Note the trees which are "not true to name" in the orchard and the synonyms in the literature. Then diseases and insects, failures in adaptation or unsuited regions of varying extent, poor culture, and seasonal influences, enter in and account for a large part of running out. A retrospective glance at the "recommended" list shows many omissions of once "popular" varieties, to the old grower; the old varieties have run out. It may be just as true to say that newer ones have run in. Speaking relatively, how about Concord and Catawba, or Elberta and Crawford?

Aside from these factors, however, there is a well-grounded belief among growers that varieties change in vigor or fail because of some fundamental changes. The influence of the stock upon the scion is supposed, in many cases, to be an important consideration. Observable changes, such as dwarfing, give ground for the implication that others less obvious are taking place. This old question may yet be regarded as unsettled. Griffon ('14) concludes, however, after an extensive investigation of variation in grafted plants, that grafting has not given rise to a "specific influence capable of modifying the fundamental character of species or of races." He states further that it is unnecessary to assume the occurrence of "asexual hybridization" to explain the infrequently observed variations. If this statement is true, nursery methods would not introduce an element which would influence the stability of the clone.

East ('08 b) says that the potato showed no running out as a result of continued asexual propaganda. "No data have been obtained which refute this view, but the study of progeny of selfed potato varieties has suggested an explanation of a certain amount of diminution in yield after long continued asexual propagation." Webber ('09) states that "clons of annual plants are rarely so stable or last so long as the clons of perennials." The life of a carnation clone is "seldom more than 10 years and the same may be said of the life of our races of annual vegetables, ordinarily."

In the case of degeneracy or the place effect in the potato we have an example of what is popularly known as running out (Kohler '09, Fitch '10, Stuart '13). Emerson ('14) found that "degeneracy" of this type could be corrected by mulching. In this case the environmental influence, largely soil temperature, ap-

pears to be responsible. East ('08 b) makes a careful summary of the evidence as to degeneration in the potato and concludes that the hypothesis seems to have "little ground either in theory or in practice." A careful study of some degenerate strains of potatoes was made by Stewart ('16). He dealt particularly with the forms of degeneration known as leaf-roll, mosaic, and curly-dwarf. He found that plants showing all of these forms of degeneration may come from the same tuber, as in Green Mountain, Jr. The following excerpt sets forth briefly Stewart's conception of the nature and origin of the above degenerate types. Assuming accuracy in diagnosis and that no accidental mixing occurred, Stewart says "the data presented indicate that leaf-roll, mosaic and curly-dwarf are closely related disorders due to the same general cause. What that cause may be we do not know. However, it may be confidently stated that it is not an organism of any kind. The writer has seen no evidence that any one of the three forms of degeneration is communicable from one plant to another except through the seed-tuber. Neither can the cause be ascribed to any weather or soil condition of the current season. Normal and affected plants may grow side by side in the same soil under the same weather conditions. Their hereditary character and the fact that normal and affected plants may come from different buds of the same tuber suggest that three forms of degeneration have their origin in bud-variation. On the other hand, the fact that plants may be affected with leaf-roll and mosaic in widely different degrees is opposed to this view. Usually, bud-varieties are more constant in their characters. Also, it is very unusual for the same sort of bud-varieties to occur so frequently as do these three kinds of degenerate potato plants."

It remains for future investigations to show whether all of the influences summed up by running out are now known. Continued vegetative propagation is not necessarily a factor since in some forms, as the grape (*Vitis vinifera*), the yam (*Dioscorea sativa*), and the fig, propagation by this means for centuries has been practiced with no apparent effect (Duggar '11). It is evident, however, from the foregoing that opinions vary as to the actual occurrence of running out. A distinction must be made between those influences more or less temporarily and, broadly speaking, arising from the environment, and genetic changes. It appears that there are non-genetic influences, more or less permanent, which result in a decrease in vigor, size, or yield which are of importance from the commercial standpoint. Weismann's test as to the permanence of an influence from the hereditary standpoint can be applied in connection with those factors causing running out, *i. e.*, a certain change resulting from a given influence must persist when the influence is removed.

Summary: The following are some of the points which may be restated in summarizing this paper. Sex and vegetative propagation both exist in most fruit varieties. Both processes can be used as methods of obtaining new individuals, yet from the standpoint of heredity they are fundamentally different. The taking on of sex by

plants has not changed the independent relation between the parts.

Relatively few of our commercial varieties have originated as discontinuous somatic variations, or "bud sports." In the apple, cherry, grape, and plum, out of a total of 2,664 varieties, 5 are believed to be bud sports, both parents being known in 146, one parent in 265, and neither parent in 2,248.

Variations in clonal varieties may be grouped broadly under fluctuations, or non-inheritable variations, and discontinuous somatic variations of a genetic nature, which are completely or partially inherited in seed progeny and which propagate true asexually.

Discontinuous somatic variations have occurred with many different characters in a large number of widely different forms. These have included size, color, lobing, season, stature, yield, pubescence, fertility, and abnormalities.

Many horticultural varieties are of hybrid origin and are characterized by extremes of the substratum or genotypic complex. Since these extremes are carried forward asexually almost indefinitely in fruit clones they may be of influence in clonal permanence.

Permanence in the clone depends upon the exactness with which the germ plasm is fractionated. In the older fruit varieties it is evident that cell division has been subjected to severe tests.

The observed irregularities in chromatin distribution would account for discontinuous somatic changes on the basis that the chromosomes carry the hereditary factors. Irregularities in division would affect character expression in so far as the factors concerned are affected.

In the clone, reduction division does not occur in the line of descent, so that segregation in the Mendelian sense does not take place; yet somatic changes are comparable to segregation in reduction division in that chromosomes as carriers of factors are affected in whole or in part, and in somatic or germinal tissue we are dealing with the same germ plasm and the same factors. From this standpoint discontinuous variations in clones can be reduced to a genetic basis and clonal permanence can be considered apart from fluctuations and the effect of selection in varying a character.

Selection experiments in clones have in some places given positive results and in some negative. The difference undoubtedly is with the material rather than with the method. The question involved is whether or not selection is based upon variations which have a genetic basis.

In the main, most commercial varieties can be reproduced relatively true vegetatively, but owing to the nursery methods, variations of infrequent and local origin may have a far-reaching influence in that within the variety the off type would be widely disseminated.

Other influences of a non-genetic nature, such as senility and disease, may affect clonal permanence in varying degrees. Future studies of these will be watched with interest in this connection.

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EXPERIMENTS IN BUD SELECTION WITH THE APPLE AND VIOLET AT GENEVA.

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In presenting this report we will not attempt to throw any light upon the immediate problem of bud selection. Our experiments at Geneva have not progressed far enough as yet to make that possible. What we do wish is to outline the plan of the work and to discuss some of the difficulties involved because we believe this may aid to a better understanding of this type of problem.

In 1896 plans were completed by Prof. S. A. Beach, then Horticulturist, for a fertilizer experiment with the apple at Geneva. To reduce the variable factors as much as practicable, Ben Davis trees that were as nearly alike as possible in height, caliper, mode of branching and character of root system were selected from a single nursery block. After planting, these trees were top-budded to Rome Beauty, all the buds coming from a tree which had stood in the Experiment Station orchard for many years.

In 1911 when Prof. Hedrick decided to undertake experiments in bud selection in the apples, he saw that this orchard, then in its fifteenth year, offered an unusual opportunity for such work. Northern Spy roots were secured and these were budded from the best and the poorest Rome Beauty trees in each of the five fertilizer blocks. Twelve trees of each kind were planted under fairly uniform soil conditions.

Although the original trees from which the buds were taken have not all of them retained the same relative rank, nevertheless, the changes are not great enough to be of much importance. As the parent orchard becomes older and we become more familiar with its performance and with the soil we are beginning to realize the extent to which position in the orchard has determined the high and low yielding trees.

In the spring of 1911, eighty-four Baldwin trees were secured from forty different sources scattered over the entire country. These were planted in a privately owned orchard near the Experiment Station. These trees had, of course, been subjected to widely different environmental conditions and were varying degrees removed from the original Baldwin tree. These trees have not received the best of care and the soil conditions in the orchard have proved to be rather lacking in uniformity. For these reasons and because of the great possibility of variation in the root stock, it is doubtful if any definite conclusions can ever be drawn from them though it is possible that variations in shape and color might be seen. We are now planning to repropagate these trees on Northern Spy roots and to plant them on the Experiment Station grounds under as uniform soil conditions as we can secure. If we can eliminate the variable factors to a sufficient extent these trees should give us some idea of the stability or lack of stability of this variety.

Recently the use of the term "pedigree" by some of the fruit nursery companies has made it seem desirable to hasten these experiments in bud selection. For this reason it was decided to work with some plant where a generation could be secured more rapidly than with the apple. The double violet seemed to offer desirable material and it was decided that the length of the blossom stem was the simplest character to use. In the autumn of 1914 eight hundred Marie Louise plants were purchased from a commercial house. For commercial stock the plants were uniform and vigorous and made a good start.

The house set aside for the violet experiment is the south one of a range of three. Adjoining it at right angles on the west is a palm house; to the east, and also at right angles, but separated by a narrow alley, is another house. This east house is on a lower level and does not appear to influence the light, though it does protect from the east winds. Owing to the position of the houses on the west and north, the southeast half of the violet house gets somewhat better light than the northwest half. On the other hand, the prevailing winds are from the southwest and in the coldest weather there is frequently a difference of as many as four degrees between the exposed southeast corner and the sheltered northwest corner. The fact that the house is twenty-five years old does not help to maintain the desired temperature.

The plants are placed in two benches running east and west and separated from each other and from the walls of the house by passageways. In discussing the data these benches will be spoken of as the north and the south benches. We give this detailed description of the house location because, much to our surprise, we are finding that the factors influenced by location—heat and light—are having a very considerable bearing upon the experiment. Perhaps a few words should be said as to the general methods of handling the plants. Through the summer they are grown in cold frames. They are brought into the house about September first and are ready for their first picking about the middle of October. Each stem is measured to the nearest half-inch. The harvesting is continued until the first of March when the plants are allowed to form runners from which the cuttings are made for repropagation.

Although the main problem is the study of stem length we have also tabulated the data for yield and in our selection have made four groups: those having long stems and high yield; those having short stems and high yield; those with long stems and low yield; those with short stems and low yield. As the experiment goes on we will probably have to throw less and less emphasis upon yield in order not to interfere with our selection for length of stem. The data for two years of work are, of course, not sufficient to throw any light upon the problem of asexual inheritance and it will not be worth while for us to give any of these data which bear directly on this phase of the work. These two years have, however, enabled us to make a general study of the violet and of some of those factors which influence stem length and yield.

With the mixed population of the first year, we confined our work to a study of house constants and frequencies. As stated before, position in the house was found to have considerable influence upon plant performance. In chart 1 we have plotted the yields of the two benches for the first year, grouping the plants by two rows of 16 plants, these rows running across the benches. The straight lines have been computed for these series of values.* From these straight lines we see that the east end of the house is more favorable to production than the west end and that this con-

dition is accentuated in the north bench. If it were possible for us to plot a curve for intensity of light we would get similar results due to the position and surroundings of the house. The sudden drop at the east end of the south bench is probably due to the low temperature at this corner.

The effect of position upon stem-length during the first year is not as clear because the changes are smaller and more easily confused with other factors. In chart II we have plotted the average stem-length of the plants by groups of two rows and computed the straight line for these series for each bench. In the south bench the negative slope of the line may be explained by the fact that plants grow more spindling in poorer light and hence the stems would be longer as we approach the darker end of the house. We would expect this condition to be the same, or even to be accentuated, for the north bench yet the line of the whole bench is nearly flat, but if we drop off the last ten rows at the east end and compute the straight line for the rest of the bench, we have a greater negative slope than in the south bench. At the east end of this bench where these ten rows were, the plants seemed to find conditions especially suited to their needs as is shown by the fact that from these we selected a very high proportion to repropagate in our long stem, high yielding group for the following year. The better light and the more uniform heat are probably responsible. Another factor which perhaps served to give these last ten rows a higher average was the death of several plants very early in the year before the bed got nicely started. This removed the weaker plants and gave the remainder more light and room. It seems fair to drop these ten rows in considering the effect of light upon stem length in this north bench.

In charts III and IV are given the frequency curves of yields and stem lengths for the first year. Upon these we have plotted the extreme points used in our selection for both of these factors and also the mean values of our four groups. Turning back to chart 1 we can see that we could place a block of one hundred plants in each of the two benches in such positions that the place

* At the suggestion of Dr. H. H. Love, of the College of Agriculture, Ithaca, N. Y., the following formulae were used in computing the straight line:

$$\begin{aligned} Y &= MX + N. \\ \Sigma Y &= \Sigma MX + \Sigma N. \\ \Sigma XY &= \Sigma NX + \Sigma X^2M. \end{aligned}$$

The use of these equations can be explained by reference to Chart 1. In this, Y equals the average stem length of each group and is plotted as an ordinate. X is the unit distance along the line of abscissas. To simplify the calculations this unit distance is represented by one. The first value from the origin is given an X value of zero. In the north bench the equation for the first value of Y then becomes:

$$\begin{aligned} Y &= MX + N. \quad XY \quad X^2M. \\ 257 &= M0 + N. \quad 0Y \quad 0M. \end{aligned}$$

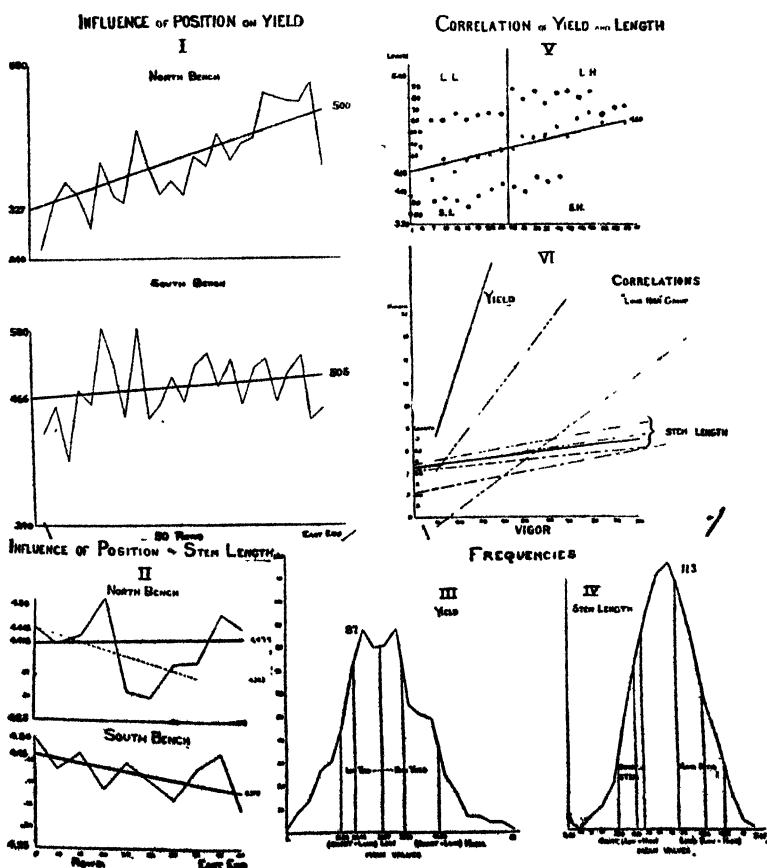
The second value of Y is then:

$$238 = M1 \quad N. \quad 338 \quad 1M.$$

When all the equations are arranged in this way the summations are taken. The value of N is then the origin of our line and the value of M is the slope.

variation in yield would be nearly as great as the difference between the lowest mean in our high yield selection and the highest in our low yield selection. Although the place variation in stem length, as shown by chart II, amounts to less than one-tenth of an inch, nevertheless this is sufficiently large to be a very serious factor in studying the fluctuations of groups of plants which might happen to fall year after year in locations of extreme variation.

We thought the lack of uniformity in house conditions and the resulting variations were sufficiently complicating, but it was not until we began to study the correlations of some of the factors involved that we began to realize the extent of our troubles. The straight line in chart V illustrates graphically the relation which existed between total yield and average stem length in the mixed population of 1914-15, + a correlation whose coefficient is 0.4273 ± 0.0202 . This line was determined from the formulae discussed



previously from the series of points representing the average stem lengths of the various yield classes. Upon this chart we have plotted the average stem lengths of the yield classes in the four groups of plants selected for further propagation. These are represented by the circles.

At this point it is probably well to state that the coefficient of variability (the ratio of the standard deviation to the mean) of the stem length for the mixed population is 5.8 ± 0.101 . This shows that stem length is sufficiently stable to make it a desirable character to use in such a problem as this. Unfortunately, we did not realize, the first year, the extent to which the vigor of the plants would influence the experiment and so did not take careful record of this factor. The second year the plants were graded for vigor twice, once at the end of the first group of seven pickings and again just at the end of the harvest period.

In chart VI we have a graphic illustration of the correlation of stem length and vigor through the twenty-one harvests of 1915-16 divided into three groups of seven pickings each for the group of plants selected for long stem and high yields. For the total period the coefficient of correlation of stem length and vigor is 0.778 ± 0.18176 . On this same chart is shown graphically the shifting of the yields for the three periods of harvesting and for the total harvest. The coefficient of correlation for total yield and vigor in the "long high" group is 0.7546 ± 0.191 .

The slope of the four lines showing the relation of yield and vigor for the three groups of seven pickings each, and for the total as compared with the slopes of the corresponding lines for stem length, show a seasonable fluctuation of the relaxation between yield and stem length. The previous year in the mixed population this correlation was about forty-two for the whole year. Because of this seasonal fluctuation we can place but little reliance upon this value. When we stop our harvest in March in order to start repropagation, we are in a period of heavy yields. If we were to shift the date of closing either way by two weeks we could materially change this correlation of yield and stem length, and yet, naturally, we had expected to place much reliance upon this very same correlation in studying fluctuations in succeeding generations.

Although the lines plotted in chart VI are for the plants selected for long stem and high yield, the same general conditions hold in the other three groups.

We have presented these results with but one thought in mind—to show the pitfalls which surround such a problem as bud selection—in order to secure criticism which may be helpful to us and to others working along these lines.

IMPROVEMENT OF VEGETABLE VARIETIES BY SELECTION.

BY RICHARD WELLINGTON,

Experiment Station, University Farm, St. Paul, Minn.

The improvement of vegetable varieties by selection is an old subject which has probably been discussed since man began to cultivate and fertilize wild plants. The methods used in selection, however, have changed from time to time and especially since the discovery of the report of Mendel's experiments in 1900 and the appearance of Johannsen's work on pure lines in 1903. Previous to the reappearance of Mendel's work, the entire plant was generally considered the basis of breeding experiments, but now that it is known that certain characters within the plants are composed of either simple or complex units which segregate during reduction division according to a definite law, we are concentrating our attention on genes, factors, determiners, intensifiers, inhibitors, etc. Again, before Johannsen's work was published, the variety was usually taken at the basis for selection, but now our attention is confined largely to individual plants and we think of them according to their genetic composition as genotypes, biotypes, and phenotypes. With these new tools or hypotheses we should be far better equipped to improve vegetables than our predecessors.

There may be a need for new varieties of vegetables for special conditions, purposes, and markets, but there is a far greater need for improvement of those that we now have. Valuable work in selection is, of course, being done and has been done by private individuals and by investigators in the agricultural experiment stations, United States Department of Agriculture, and other institutions, and yet the field has scarcely been scratched. Each variety of importance should be separated into all its possible components, and these components should be thoroughly tested as to their vigor, productiveness, and resistance to disease and adverse conditions; and recombined, where possible, to determine whether beneficial effects would be derived from crossing.

In order to advance selection work as rapidly as possible, I strongly urge every one who possibly can and who has not already entered this field to do so at his earliest convenience. By dividing the varieties among the experimenters most favorably located and equipped to handle them, the burden of improving many kinds would not fall heavily on the shoulders of a few and the total results would be very great. Investigators in the states of Washington and New York, for instance, might improve the cauliflower varieties, while others less favorably located could work on the onion or some other vegetable. If more than one investigator wanted to work on the onion, the varieties of this vegetable might be divided among them, according to the importance of the varieties in their respective regions. Co-operation of numerous investigators would require the use of uniform methods of procedure and uniform rec-

ords, in order to obviate confusion in the interpretation of results, but this is only a minor phase of the main problem.

Roughly speaking, the methods of procedure would depend largely on the method of propagation of the particular vegetable. For example, corn, squash, and other plants commonly cross-fertilized would have to be selfed and the inferior strains preserved by "heterosis," isolated. Perhaps some of these unproductive strains may have a value when combined with other strains, and so, where feasible, they should be thoroughly tested before discarding. Tomatoes, peas, and beans, on the other hand, which are commonly self-fertilized, probably carry along fewer inferior types than the cross-fertilized plants, but even these vegetables, as experiments have proved, can be improved by eliminating the weak individuals and preserving the strong. Asexually propagated plants, as the potato, should be free from degeneration, but practically they are not, for weakened individuals appear more or less frequently and reduce the yield directly in proportion to their number.

At the Minnesota Agricultural Experiment Station considerable attention has been devoted, in the last three years, to the improvement of vegetable varieties by selection, and already important results have been obtained. In order that vegetable investigators may know what work is in progress it is deemed advisable to publish a preliminary report. The vegetables under investigation are the cucumber, lettuce, tomato, squash, canning pea, bean, onion and potato. These have been selected because of requests from growers, their commercial value, and time of ripening. It is obvious that crops maturing at different seasons allow a more economical distribution of labor and funds.

In the cucumber, individual plants from several varieties have been isolated and their fruits studied. Great variation was noted in the type of fruit borne by different plants of certain well-known standard varieties, as the Davis Perfect, and very little variation in others, as the White Spine and Lochie Perfection. The experiments so far indicate that it will be possible to secure more uniform types of this vegetable.

Plants selected from a variable or mixed lot of Big Boston lettuce, and selfed, have thrown light on segregating characters in this vegetable. Two leafy plants split into loose, head, and intermediate types, indicating, as Durst pointed out in last year's report of this Society, that the heading character of this plant is composed of more than one unit factor. Heads tinged with red gave pure greens and reds of varying degrees, the proportions also substantiating Durst's statement that green color behaves as a recessive to red. A variation of about ten days occurred in the time of heading of the original lot, and it is hoped that this early heading characteristic can be fixed to an otherwise desirable type.

In studying the influence of crossing in increasing the yield of tomato varieties, records were kept of pedigree strains, and the data obtained corroborated the work of Myers at the Pennsylvania

Experiment Station. Great differences were found in the productiveness of strains isolated from standard varieties, notably the Earliana, in which a calculated variation of ten tons per acre occurred in 1915. The highest yielding strain produced smooth fruits and gives promise of being a valuable acquisition, especially as it outyielded, in 1916, a strain whose seed is valued at \$5 per ounce. A surprising incident is that in 1916 the lowest yielding strain of 1915 outyielded the highest yielding strain of the same year by a small margin, even though it produced ten fruits less per plant. This reversal in productiveness was undoubtedly due to the excessive heat and drought which occurred when the high yielding strain, which was earlier, was ripening the major part of its fruit. On the contrary, the cool wet weather in 1915 undoubtedly assisted in making an abnormal increase in the yield of the earlier and more prolific strain and abnormal decrease in the later ripening strain. Considering the pros and cons of the case, the 1915 high yielding strain, especially since it produces more fruits per plant, will undoubtedly maintain its lead during a normal season, but in a less marked degree than in seasons similar to 1915. This incident is mentioned to emphasize the necessity of conducting tests for several years before drawing definite conclusions, and to call attention to the fact that yield is not always an absolute criterion of the value of a plant.

Of the different vegetables tested, the Hubbard squash appears to be giving the most marked results. Several distinct strains, remarkably uniform in shape, color, smoothness, wartiness, and thickness of flesh have been isolated and if one of them or a cross between them is more productive and more nearly uniform in desirable characteristics than the stock now on the market, a distinct gain will be made for the squash industry.

In the Alaska pea and the variety of the Refugee bean, 1000 to 1, many strains have been isolated and in several cases the productive mother plants have given productive progeny. The yields of the bean strains were not taken this year, as the blossoms dropped during the hot and dry weather. A severe attack of thrips and red spider probably also aided in the blasting of the flowers. A small quantity of seed, however, was gathered, and a great variation in the prevalence of blight was noted on the pods of the different strains. This difference in disease resistance was so striking that it seems worth while to make tests to determine whether it is accidental or due to physiological or morphological causes.

Next to the squash, the onion has given the most striking results. Numerous strains have been isolated from individual bulbs, which vary in shape, size, color, and keeping quality, and the splitting of the types after selfing has given indirect information on the segregating characters. One strain gave promise of being exceedingly valuable, as it was not only remarkably uniform, but an exceptionally good keeper. Unfortunately this good keeping quality proved to be associated with a weakness in the production of seed,

and so it is doubtful if the strain can ever be propagated on a commercial basis. However, uniform strains have been isolated which do not possess apparent weaknesses and perhaps at least one of them will pay for the expenditure of time and effort on this crop.

Selection experiments on the Early Ohio and Sir Walter Raleigh potato varieties have been made at University Farm, and after two seasons the tubers became too small to be used for seed. However, when the same varieties were grown for one season at University Farm and the following season at Duluth and Grand Rapids, degeneration has not appeared. Identical varieties grown within a few miles of University Farm, but on different types of soil, also have not suffered a loss in productiveness and vigor, and therefore the so-called running-out or degeneracy is evidently due to the soil rather than to climatic conditions and diseases. These results indicate that when potato varieties degenerate rapidly on account of adverse conditions, time and effort can be more profitably expended on other problems than selection.

In closing, I wish to call attention to the value of selection experiments in improving vegetable varieties as research problems for graduate and advanced students. The large number of varieties and the many characters that may be improved, give an almost unlimited number of problems to draw upon, but in order that the student may secure immediate results it is advisable to start him on a project that has been in progress for at least one or two years. By organizing and concentrating the attack on the improvement of vegetable varieties by all known forces, it should be possible within a few years to save producers and consumers thousands if not millions of dollars annually.

FRIDAY, DECEMBER 29, 10:00 A. M.

VARIETY TESTING.

By L. C. CORBETT,

United States Department of Agriculture, Washington, D. C.

In the broad field of horticulture we have two classes of varieties. One is represented by the apple, the pear, and other vegetatively propagated products. This group we may call, for our convenience, stable or fixed varieties. The other class of varieties may be represented by cabbage, beets, or radishes, in fact by any seed propagated variety. This group consists of fluctuating or plastic varieties, but even in this group each name of a variety should stand for a definite concept and, in fact, for a definite entity possessing a certain combination of attributes. No two individuals reproduced through the medium of seed reproduction ever possess the same combination of attributes in exactly the same degree. In this

class of varieties therefore there naturally exists a certain normal latitude of fluctuation.

In pure strains of many horticultural varieties, even though perpetuated through seed, we find the individuals in the progeny resembling one another so closely that they can only with the closest scrutiny be distinguished one from the other; and when true morphological characters are considered and somatic characters which are subject to fluctuation ignored, the approach to constancy in such progeny becomes even more pronounced. In such a line-bred population we find suitable material for worth while variety tests.

From what I have said it will be gathered that any population worthy of a name of a variety must in the first place possess a definite combination of morphological characters so persistently reproduced in all the individuals of that progeny that they are difficult or impossible of individual identification, that is, a population consisting of individuals the dominating characters of which are class or variety characteristics rather than individual characteristics. In reality the class characteristics observed in a population deserving the name of a variety are the individual characteristics of the progenitor of that variety transmitted to its offspring. In seed propagated plants such a population is most likely to be secured through progeny row selection, and when once obtained it can only be maintained through a continuation of the system.

But when we consider the products of the trade, particularly the vegetables propagated by seeds, we find altogether another story. With the exception of a few stocks developed by plant breeders, our commercial vegetable seed is made up not of line bred stock developed from a single ancestor, but as a rule from several plants showing desirable attributes or characteristics. The seed of these plants is mixed to form stock seed for the following season's supply. If any considerable number of "offs" or undesirable plants appear in this crop, they are (theoretically at least) rogued for the purpose of eliminating the undesirables. From what is now known of the behavior of the progeny of individual plants when subjected to line breeding it is evident that any lot of seed derived from a mixed ancestry can never be reduced to the close limits possible with line bred products from a single individual of superior merit. To prove that the vegetable seeds offered by the trade are, for the most part, of this conglomerate character, I need go no farther than to call your attention to the condition presented by a sample of seed of any of the so-called varieties of beets now available in the trade. Practically every sample of seed of any of the turnip rooted beets will be found to contain 50% or more of roots resembling more or less closely the form and other characteristics of the variety, but the remaining population will be made up of an admixture of all possible variations of the turnip rooted beets.

I dare say that outside of the work done by Prof. Wm. Stuart, there is little trial work with potatoes that is worthy of the name.

Before he undertook to establish pure strains of the varieties in the trade by progeny row and hill selection methods, there was no material available which could be used as the basis of a real variety test of potatoes. Before this purification work was done, we were merely comparing one mixed lot with another mixed lot, and from the results of comparing one mixture with another mixture, the industry was enlightened in regard to which was the best, what shall I say—variety or mixture?

If the material we use as the basis of a vegetable trial is itself 50% or more "off" type, pray tell me what do we get by comparing different lots of such material?

With most other vegetatively propagated plants the problem is quite different, for with them we simply divide the individual and, save for bud variation, we secure a constant or fixed population, each individual of which possesses the characteristics of the progenitor of the sort. With these concepts of what constitutes varieties as measuring sticks, let us for a brief interval review horticultural activities to determine what has actually been done in the way of testing or comparing varieties.

If we accept the nomenclature of fruit varieties as accurate, then we are forced to accept the variety trials with budded or grafted fruits as falling within the scope of our concept. But even so, what can we say of the basis upon which such studies have been conducted. For the most part, such studies are not comparable because no two investigators use the same outline for note taking and consequently one observes characters not noted by the other and even when the points of observation are nominally the same, the objects of the studies have been different and as a result the observations on supposedly the same features vary.

Variety trials conducted with comparable materials and by the use of the same study outlines possess a variable factor in the individuals making the observations. To reduce this to a minimum a system of note blanks has been devised for varietal studies with vegetables which goes so far as to limit the phraseology of the observer. This, together with the use of statistical methods for recording the performance record of the population, goes a long way towards making the work of different observers comparable.

The variety test of the future of seed-propagated plants, will be based on line-bred progeny, recorded on uniform blanks designed to interrogate each variety of any class of plants in the same manner and by the use of the same set of questions. These questions based upon the morphological characters of the species, are so supplied with terms expressing variation from the normal as to include the full range of the possibilities of variation in the species and thus allow for a rapid and complete notation of the characters and qualities possessed by any variety.

Such questionnaires, when properly used, not only bring out the distinguishing characters and qualities of each sort, but they make it possible to determine the characters in which one sort differs from another.

Accurate descriptions made on such forms can be used as a basis for the identification of varieties and to show the differences existing between varieties.

In the light of what has been said regarding the constitution of varieties and the dangers and pitfalls along the road of ordinary variety testing, the value of such record blanks becomes at once apparent.

In the development of this set of variety note and description blanks we have merely made an attempt to place at the disposal of all who wished to make use of them a set of note blanks which would to a degree enable each student, wherever located, to do something to supplement the work of every other student or investigator using the same outlines and working with comparable material.

Another object of this attempt has been to give a new impulse to the work set in motion by Dr. Sturtevant before and during the period of his directorate of the New York State Experiment Station. No one since his time has approached the problems of variety testing with the keen perception of the diligent painstaking methods used by him, and as a result, variety testing has come to be the joker of experiment station lore. The reason for this is not far to seek, for neither the ones conducting the work nor those criticising it have given the subject careful constructive consideration.

The importance of the problems involved in well conceived and well executed variety trials is appreciated only by those who have undertaken to establish a new industry or remedy some pronounced difficulty in a waning industry.

A case in point is the difficulties attendant upon the establishment of the Calimyrna fig industry. The maintenance of a Vini-fera grape industry in North America is another severe test of every device known to the student of variety testing. These investigations have developed a field of varietal study not before recognized and even now but inadequately appreciated, namely that of congeniality of stock and scion. A hint that such a field existed has been noted by various students since the time of Knight, but it remained for Husmann through his grape tests to demonstrate the far reaching importance of this factor. Oliver, in his vegetative propagation of the leguminosae has also demonstrated the same fact. The Glory pea gave the first evidence, which was later followed by demonstrations with various alfalfas. The evidence available, though meager outside the genus *vitis*, is nevertheless sufficient to warrant much larger attention to this field.

Bud variation is a factor that had not, previous to the carefully planned studies of Shamel, been taken into consideration in varietal studies with budded and grafted fruits.

The remarkable range of bud variation and its important bearing upon commercial aspects of the citrus industry in California are set forth in bulletins which will soon be available from the United States Department of Agriculture. The variety or strain tests, which form the basis of these publications, will furnish inter-

esting mental pabulum for those interested in some of the future possibilities of variety testing.

What has been found to be true of the citrus varieties of California will without doubt be found to exist to a greater or less degree with other classes of vegetatively propagated horticultural products.

The grape work has demonstrated the importance of the congeniality as well as the adaptability factor in variety studies. The citrus work has clearly brought to our notice the destructive influence of unsuspected bud variation, and the cold storage investigations with apples has clearly demonstrated that not only do varieties differ widely in their behavior in cold storage, but that the fruits from different trees of the same variety show varying responses to like storage conditions.

Variety testing is probably not made easier by the facts to which I have called attention, but future variety testing should become infinitely more interesting and valuable.

From what I have said, it will appear that before we can test or compare varieties we must have a population which answers to a reasonable definition of a horticultural variety. Strange to say, such a definition is not found in the opening paragraph of every horticultural text, yet every student as well as commercial horticulturist speaks glibly of varieties. To clarify the situation some what, I wish to repeat the definition of a variety given in the first paragraphs of this article, which is to the effect that *a variety consists of a population of individuals possessing a definite combination of morphological characters so persistently reproduced in each that individual identification is difficult or impossible.*

That depending upon the method of propagation there are two classes of varieties—those vegetatively reproduced may be considered stable while those reproduced by means of seed are plastic.

In order to study, compare, or test such varieties these fundamental factors must be considered. The first practical question to arise in connection with a variety test should involve the material itself. Is it true to name and is it pure? These two qualities must be possessed by the material in order that it may be considered suitable for variety testing, in which the object is a comparison of merit or value.

But as has been pointed out, variety testing can be undertaken from a great many points of view; the value of work depending upon the concept of the worker, the material, and the methods followed.

VARIETY TESTING AT THE DOMINION EXPERIMENTAL FARMS, AND WHAT HAS BEEN ACCOMPLISHED BY IT.

By W. T. MACOUN, *Central Experimental Farm, Ottawa, Canada.*

In a country as vast as the Dominion of Canada where there are many kinds of climates ranging from the arctic and sub-arctic to that on the west coast of British Columbia where but few degrees of frost are recorded, it requires many varieties of fruits to meet all conditions. In some parts of the Dominion the summers are warm but the winters cold; in other parts the summer is warm and the winter relatively mild; or again the summer may be cool and the winter mild, or the summer cool and the winter cold. Spring frosts frequently catch the early blooming varieties in one district, while in another, the short growing season prevents the full development of the fruit.

Before referring to the results obtained from testing varieties of the different kinds of fruits at the Dominion Experimental Farms and Stations, a statement should be made of the kind of testing which is done. It is the aim to plant at least two trees of each of the varieties of tree fruits which it seems desirable to experiment with. If the prospects of the tree, being a valuable acquisition, are good, more trees are planted. After a variety has been proven to be promising, from eight to twelve trees each of a number of promising sorts are planted side by side with well tried varieties, in order that a better idea of their commercial value may be obtained than if but two were grown. It has not been considered a good test of a variety to top-graft it, as it is important to learn whether the trunk will withstand sunscald or fire blight, and this can only be learned by growing a tree with its own trunk. It is a temptation, however, to do some top-grafting in order to see what the fruit is like as soon as possible. Records have been kept every year at the Central Experimental Farm, Ottawa, since 1898, of how the trees of each variety winter, the time when each variety begins to bloom, is in full bloom, and when the bloom has fallen; the kind of crop, whether light, medium, good or whether there is none. This is followed up by actual measurement of the yield in gallons, the yield being divided between picked fruit and windfalls, several pickings of the latter being usually made. Annual notes are also made of the way and degree in which each variety is affected by disease or insects; the season's growth of each tree is also noted, whether it is weak, medium, or strong, and when the variety has fruited a detailed description is made of the fruit; the keeping quality of the fruit is also determined. Not only are these notes made of each variety, but of each tree of each variety. The same kinds of record-books are used at all the farms and stations, and, as far as possible, similar notes are now being taken at most of them, as at Ottawa.

In testing grapes two or more vines are planted. One of the most important records kept of grape varieties is the time of ripening, and whether a variety ripens at all or not. Notes are also taken in regard to the blooming season and kind of crop, and description of the varieties are made. The minimum number of currants and gooseberries usually used in a test is six, and of raspberries, twelve plants, or hills. The hardiness of the plants is recorded, and the length of the fruiting season. Descriptions are made of the fruit. At some of the newer stations rows of currants are alternated with rows of raspberries, to avoid mixing of the varieties from suckers.

The variety test of strawberries is usually conducted on plots consisting of two rows each 15 feet in length, 20 plants being set out, 10 in each row, the plants being planted 18 inches apart, and the rows made $3\frac{1}{2}$ feet apart. The strawberries are grown by the matted row system. The plants are not thinned out, but the rows are all reduced to two feet in width before growth starts the second spring. Two rows of 15 feet each, rather than one row of 30 feet, are used, in order to prevent the possibility of the plants getting mixed, the plants for a new plantation being taken from between the two rows. Larger areas are planted of the older varieties and the best of the newer ones. Nearly 700 named varieties of strawberries have been tested during the past twenty-eight years. Some of the more important annual notes made upon the varieties of strawberries are in regard to hardiness, blooming season, character of plant as to vigor and plant-making habit, amount of disease, length of fruiting season, ability to keep up size during fruiting season, and the yield. Finally, descriptions are made as with other fruits.

There is not time to go into the details in regard to each kind of vegetable, ornamental tree, shrub, and ornamental herbaceous plant, suffice it to say that many hundreds of varieties have been tried, and notes taken. In the case of vegetables and annual flowers which are raised from seed, strains play a very important part and this has to be taken into consideration when deciding on a variety.

So much has been said in regard to methods of testing varieties. What can be said of the results obtained. In the case of the apple, which is the most important fruit grown in Canada, and which will be considered first, much useful information has been brought out which may be grouped under various heads.

Hardiness. The first consideration in regard to a variety in Canada is its ability to withstand the cold or changes of temperature in winter, and hardiness has that meaning here. When the first experimental farms were established in 1887, the great diversity of the climate was realized and it was felt that one of the most important lines of work that could be undertaken was to determine which varieties were most suitable for the parts of Canada represented by experimental farms at that time. There were but five farms established at first, namely, the Central Farm at Ottawa,

Ontario; and Branch Farms at Nappan, Nova Scotia; Brandon, Manitoba; Indian Head, Saskatchewan; and Agassiz, British Columbia; and on these farms were planted large collections of varieties of fruits. A striking example of the result of this first variety testing may be given in the case of the Experimental Farm at Indian Head, Saskatchewan, where among others of American origin, what were thought to be the hardiest Russian apples were tried. This first testing was done on a practically treeless prairie, but even though shelter belts have grown up the same varieties have done little better in later years. From the very first, however, the wild Siberian Crab apple, *Pyrus baccata*, proved quite hardy, and has continued to bear abundantly. At Ottawa, where the winters are much milder than in Saskatchewan, but where the temperature goes down occasionally to 30°F. below zero, many varieties have been killed by winter. During the past twenty-eight years 734 named varieties, other than those originated there, have been tested. In one winter, that of 1903-4, trees of 164 varieties were killed. This was one of the so-called "test" winters of which only a few are experienced in any one man's life, but which are very valuable from an experimenter's standpoint. There are now 21 experimental stations in Canada where varieties of fruits are being tested and most of the striking climatic conditions are represented in the districts they serve. At sub-stations and by private individuals scattered here and there over the country, varieties are being tested at a large number of other places. We are well situated in Canada to determine the relative hardiness of different varieties as the minimum winter temperature at our station varies all the way from twenty to nearly one hundred degrees of frost. Results have shown that it is not always the extremely low temperature which kills a variety, but rather continued cold spells. In the winter of 1903-4, for instance, when so many apple trees were killed at Ottawa, there was a very cold spell for twelve consecutive days, on six of these days the temperature going to from 20° to 30°F. below zero. In other winters, when the temperature occasionally drops to from 25° to 30° below, little or no injury to apple trees occurs. Other conditions which cause killing of the trees are low drops of temperature in spring after the buds have begun to swell. It is such conditions which cause the death of many trees on the prairies which have gone through long continued spells of cold weather with little injury. Hardy varieties must then be able to withstand continued low temperatures and sudden changes of temperature. It has been learned by the testing of varieties that a very large proportion of those which ripen their wood well before winter sets in are among the hardiest. Trees which have grown late stand little chance of pulling through in a test winter. Most of the summer apples ripen their wood, and most of the commercial summer varieties are hardy at Ottawa, but varieties hardy at Ottawa are not hardy under the more trying winters and springs of the prairie provinces, hence there are degrees of hardiness even among early ripening trees. It has been found that the greatest hardiness is found

among the Russian varieties of apples, no doubt because they are the survivors of many test winters in Russia and perhaps because they are nearly related to the Siberian Crab apple, *Pyrus baccata*, which grows, I understand, very far north in Siberia. In closing these words in regard to the value of testing to determine the hardiness of a variety, mention might be made of the two well-known sorts, Fameuse, and McIntosh, the latter supposed to be a seedling of Fameuse. Up to the winter of 1903-4 it was supposed by many, and by the writer, that McIntosh was no hardier than Fameuse if as hardy, but that winter McIntosh trees were practically uninjured while many Fameuse trees were killed. There is a long gradation in hardiness among varieties of apples between Hibernial at one end and, say Yellow Newtown at the other. Information obtained in regard to hardiness has been obtained with other fruits as well as the apple. In the case of plums and cherries the trees of some varieties have been found hardy in some districts but the fruit buds were tender, the buds of these fruits being influenced by sudden changes of temperature in winter. Among raspberries it has been found that the canes of certain varieties are liable to kill back badly while others are perfectly hardy. With currants, varieties of the Fay and Cherry types have been found much tenderer than others and are quite unsatisfactory at Ottawa. The plants of some varieties of strawberries kill out badly, while others, such as the Senator Dunlap, Warfield and Crescent, are very hardy.

Yield. It is only by the careful testing of varieties that the relative yields over a period of years can be obtained. At Ottawa such yields have been kept for nineteen consecutive seasons and while the number of trees of each variety, in the case of apples for instance, is small, yet a fairly good idea can be obtained of the time when each variety begins to bear; of the fruiting habit of the tree; and of the yield which one may be expected to obtain in, say, the first ten years growth of the tree in the orchard, and for longer periods. While it would obviously be unfair to base acre profits on the performance of two trees, yet it is believed that two trees will give a fair idea of what may be expected from a larger number of the same sort. It is true that we have had about twice the crop over a long period from one of two trees of a variety, that has been obtained from the other in the same orchard and planted at the same time, yet it is believed that the larger yield will come nearer the average for a large number than the smaller and, as has been stated before, a larger number of trees of each variety is desirable. In the case of small fruits it is believed that five-year averages are desirable before one can speak with a fair degree of certainty in regard to the yield of a variety. On the other hand a new variety may be discarded in less than that time for other reasons than yield.

Keeping Quality. It is important to grow varieties at the same place and in the same orchard if one is to get the best information in regard to their relative keeping quality. If a large number of varieties is brought from many different places for a keeping test,

they may have come from quite different summer climates or have been under different methods of cultivation, which would affect the keeping quality. When so many new varieties are being originated as is the case today, especially at the experimental stations, it is important to compare the keeping quality with those already on the market, hence the importance of having a representative collection of such growing at each station.

Blooming Season and Pollination. While there is still much to be learned in regard to pollination, the records of the time of blooming and amount of bloom of each variety of each year should prove of some importance. The blooming season of the different varieties in the orchards at the Central Experimental Farm, Ottawa, have been recorded since 1895. The amount of bloom, whether small, medium, or large, of each tree, has also been recorded so that at least some idea of the relation of the amount of bloom to the size of the crop each year can be ascertained and this, with the weather records, aids in ascertaining the cause of short crops.

Descriptions of Varieties. It is important to test a large number of varieties at one place in order that the technical descriptions which are made of each sort will be true for the district which the station serves, and while there will be little variation in descriptions of fruit or vegetables grown in different places, climate certainly has some effect on color, shape, flavor, keeping quality and, doubtless, on other characters.

Vegetables and Annual Ornamental Plants. The testing of vegetables and annual ornamental plants, although giving results sooner, is more difficult in some ways than with trees and bushes. So much depends upon the strain that if one buys seed of a certain variety from a certain firm one year and the next year, in continuing the test of varieties, seed of the same variety from another firm, the relative results obtained may be quite different. The strain tests of the Pennsylvania and other stations are well known. At the same time some varieties, on the average, have certain characteristics that others do not, which are shown in most of the strains, hence it is important to try new varieties as they are introduced, even though they may not be fixed in their habits—if they have desirable qualities these can be noted.

In connection with testing of varieties of vegetables and flowers at the Dominion experimental farms and stations which are scattered over the country from the Atlantic to the Pacific, in order to make the comparison as fair as possible seeds are obtained each year from the same firms for all the stations and the seed distributed from the Central Farm at Ottawa. As far as possible, the different varieties are obtained either from the firms which have introduced them or from the firms which make a specialty of them. While there are, as stated, difficulties in the way of a fair test with vegetables, five-year tests usually bring out the good or bad points of a variety.

Publication of Results. An annual report of the experimental work is published by the Dominion experimental farms, and while

it must be confessed that the results from single year tests are often published and, in the case of vegetables, varieties which head the list one year, as regards yield, do not often do so the next, such notes as the relative height of plants, time when ready for use, description and quality, give useful information and are at least of some help to the man who *will* continue to test novelties and grow a number of varieties each year whether the experimental station considers them of value or not.

Variety testing has been one of the main features of the horticultural work at the Dominion experimental farms for twenty-eight years and it is believed that it has been well worth the time which has been devoted to it. While private individuals do a certain amount of testing themselves and some of the best growers are as quick to obtain a variety as is an experiment station, yet the great mass of the people either does not know one variety from another or else knows only a few of the old sorts. As an example of the value of variety testing in the district about Ottawa, it may be stated that it was the practice until recent years and may be to a small extent still for an agent to offer for sale varieties of fruits too tender for the district. This was done because neither the people nor the agent had a good way of finding out what varieties were suitable and many sorts had never been tried. As a result of the selling of trees of tender varieties, thousands of trees winter killed in the past. Now the agent consults the lists of varieties recommended by the experimental farms and fruit growers can do the same if they so desire. The result is that a large proportion of the trees now sold will do well if cared for.

Lists of recommended varieties of fruits, vegetables, and ornamental plants based on the experience gained at the Dominion stations have been published in the annual reports and in bulletins and have been found very useful by young horticulturists, or by those extending their plantations. It is believed that thousands of dollars have been saved to fruit growers by either guarding them against buying unsuitable sorts or by letting them know which were the best for their districts. The Dominion Government has a very large free mailing list and provides large editions of bulletins which are likely to prove useful. A recent bulletin on "The Apple, Its Cultivation and Improvement in Canada," by the writer, has an edition of 110,000 copies. In this bulletin lists of varieties are given for the whole of Canada.

For a number of years lists of best vegetables, based on results at the experimental farms, have been published in the annual reports. Lists have also been published of the best annual and perennial ornamental plants.

Nothing has been said about the work of originating new varieties for which considerable effort has been put forth at Ottawa with some promising results. There is no variety which is perfect or suitable for every climatic condition and it is believed that it will be more and more recognized in the future that certain varieties succeed best under certain conditions of soil and climate.

METHODS FOR THE STUDY OF VEGETABLE VARIETIES AND STRAINS.

BY PAUL WORK, *Cornell University, Ithaca, N. Y.*

The botanical taxonomy of the vegetable plants is fairly well established, although a few kinds have had as many as three or four specific names within a generation. The horticultural taxonomy is in a state of almost primeval chaos.

The problem has been attacked in two ways. Trials have been conducted with varying numbers of samples of vegetable seeds to indicate their relative usefulness for various purposes and under various conditions. The results are expressed in notes which in many cases are of little more value than the average seed catalogue description. Other workers have undertaken to know the whole array of varieties of a given vegetable kind and their results have been expressed in taxonomic monographs which have proved of real and permanent value. Such work is comparable to the studies of fruit varieties of the Geneva Experiment Station. Notable examples are the lettuce studies of Tracy, the bean studies of Jarvis and of Tracy, and the potato studies of Stuart. We may expect the existing confusion to continue until such studies have been directed toward all of the crops and until the work is well enough done to command respect and acceptance on the part of scientist, of seedsmen and breeder, and of crop grower.

Studies of the former type have generally been conducted on a low scientific plane. They consisted in simple and superficial tests for a single season of seed samples selected without reference to the whole range of varieties in the given crops. The data consisted of notes on casual observations, or if records were taken in a systematic way only a portion of the important characters were considered. Today the problem is attacked at the base. The origin and history of the varieties, description in previous literature, the ideals of both crop and seed growers, as well as the data derived from painstaking trials through several years and with thoroughly representative samples all contribute to the knowledge of the kind as it is expressed in the published monograph. Each worker must establish his own methods, but certain principles guide in all such studies. It is the aim of this paper to suggest considerations that should not be overlooked and to point out resources that should not be neglected rather than to lay down dogmatic rules.

In the first place a taxonomic study of the type which we have in mind is a work of years, not of one or two seasons. Unless one has already enjoyed unusual intimacy with the crop selected, it will require two years for him to become sufficiently familiar with his material to do really effective work. The notes of several seasons must be compared and discrepancies must be eliminated. It requires time to meet men, to learn their ideas and to visit their trial grounds.

The first step in a taxonomic study of a vegetable kind is the selecting and gathering of material for examination—of seed samples for trial. The history of seedsmen may well be tabulated and compared. Some workers procure samples from all. In view of the fact that many seedsmen secure their supplies of a given variety from the same source, there is needless duplication in this method. Further, in view of the fact that a single seedsman may be filling orders from two or more stocks there is danger of incompleteness. It will doubtless be assumed by many that this situation cannot be met. Seedsmen are not accustomed to say much about the sources of their seeds. However, discriminating growers have learned that they can secure seed of a single parentage from a given dealer or producer year after year and if for any reason the supply fails they are informed and they are consulted before a substitution is made.

Experience in a study of celery, now under way, has brought the gratifying realization that many of the best seedsmen are similarly willing to co-operate with the scientist to the extent of their ability. They have offered every facility for placing the study on a basis much nearer the sources than would be possible if mere catalogue samples were used. Of course, much information must be regarded confidentially and courtesy demands that the wishes of the members of the seed trade be respected. This is not at all likely to interfere with the interest of truthfulness or completeness, for the far-seeing seedsmen realize that it is inaccurate statements or half-baked truths which they have to fear rather than the whole truth.

On this basis the ideal would be that all samples come directly from the men who are maintaining the stock and that all stocks be represented. All samples should bear the grower's stock number or at least a designation that will enable him to refer directly to it.

The trial grounds should offer conditions that are possible for the best development of the crop and conditions that truly represent those under which the crop is normally produced. Lettuce should be tried on a typical, fertile market garden soil and on muck. Cabbage may be tested on a sandy loam somewhat less intensively fertilized and if possible late sorts should be compared on a heavier soil. Abnormally heavy feeding should be avoided, but irrigation may be used to insure the conditions of a good year. It is needless to emphasize the necessity for the most unvarying precision in the arranging of rows and labels. A plan on paper should make it possible to identify any planting by location. Sufficient check rows should be included to express variations in soil and site.

It is in the record taking that the difference between casual comment and systematic study appears. Records must be made at various stages of development and in such forms as to express completely the significant characters of samples. They must be so standardized as to admit of convenient and accurate comparison.

The prime function of a description sheet is to suggest points to be observed and to provide means for record. Each worker must prepare a sheet that will best suit his object and his individuality.

It may be of the United State Department of Agriculture type showing almost any term that may be required and to be filled in largely by the use of symbols. Interlined notes are, nevertheless, frequently necessary. After a worker has become thoroughly familiar with his material and his terminology, he may use a sheet with only line headings leaving descriptive terms to be filled in. This allows greater flexibility in expression of variations. A third possibility is a sheet headed with a given character and with a line numbered for each sample. This is useful where it is desirable to examine a particular feature of the plant for all samples before taking up the next feature. This method is especially valuable during the period when the worker is establishing his mental picture of the existing range of variation for a given character.

Needless to say the usage of terms must be clearly defined in the mind of the worker and care must be exercised to avoid unconscious "creeping." "Very large" may mean one thing this morning and another this afternoon. Usage of terms must be carefully recorded verbally and by reference to samples to give notes their full usefulness. The precedent of botany and of systematic pomology should be observed as far as possible. Needless confusion and obscurity arise from the exercise of undue ingenuity in devising terms and meanings for terms. The importance of keen mental application in note taking and the value of continued practice in seeing things may well be emphasized.

In preparing description sheets, discrimination must be exercised to avoid filling it with terms for characters that are not significant. The basis should not be "Thickness of flesh *might vary*" but rather "*Does* thickness of flesh vary." Furthermore, variations may exist which are without real significance either through direct intrinsic value or through correlation with other characters, perhaps hidden. As an example of the latter may be mentioned the correlation between stringiness and conformation of tip in garden beans.

It is frequently helpful to arrange samples in order according to a given character and numbers may be assigned to positions in their order. Thus five degrees of greenness of foliage may be designated as 1, 2, 3, 4, and 5. Actual measurements should be employed wherever possible. "Small," "large," "very large," may well give way to the average height and weight of ten random or ten typical specimens. Here again the value of records depends upon care in describing conditions under which they are taken and in seeing that those conditions do not change. For example, how is the length of carrots to be measured? An arbitrary decision may call for length from the crown to the point where the tap root is $\frac{1}{4}$ inch in diameter. Even this is not precise, but it renders notes comparable.

The whole tendency thus indicated is toward mechanical note taking. The worker must guard against becoming a mere machine and he must apply his mind to the formation of clear cut mental pictures of types and of their variations one from another. Formal note taking must be accompanied by the writing of verbal descriptions or characterizations which would convey a definite impression

to the reader. Thus may the practical usefulness of the work be preserved.

Selection must be made among the many forms of illustrations which may be employed to support formal records. The botanist speaks of the type plant for a given species which may still be seen, perhaps at the Gray Herbarium. Photographs, drawings—both schematic and perspective—color reproductions, herbarium specimens, and specimens preserved in liquid all have their places in making permanent records of types. Perhaps the worker who undertakes to master radish varieties will select a few plants conforming to his standard description of a given variety and will perpetuate his ideal of it by propagation from year to year. We will not take time to deal with the relative usefulness of these various record forms. It may be added that they are just as useful in defining terms as in recording variety types.

During the process of description making, the worker has considered the usefulness of various characters for classification and key making and he has formed opinions as to the proper bases upon which judgments as to synonyming may rest. He must use his descriptions, but he must also consider origins, customs and commercial utility. At this point he comes into contact, if not conflict, with the seedsman and the crop grower.

In this work he will require his best judicial ability and his best personal tact. In the celery work already referred to, a questionnaire has been very serviceable in getting the viewpoint of crop growers regarding the essential characteristics of varieties as to market requirements and the improvements they could ask.

It is one thing to present the results of a careful study of the synonyming of a given kind. It is quite another to bring this scheme to acceptance by the seed trade. No kind has ever been reformed. The conflict between commercial interest and scientific idealism will doubtless persist. The progress that has been made in standardization with cattle breeds, the recognized desirability of substituting order for chaos and the fact that such a bulletin as Jarvis' on Beans is widely accepted among the trade, all support the view that the task is not hopeless. The chance of success rests upon the excellence of the work and upon the co-operation of all interests involved. Eventually there will be needed a recognized board of review such as has been suggested by the Vegetable Growers' Association of America, and which will decide, after trial and comparison, whether a submitted sample is worthy of standing as a new variety or singly as strain or stock. In this work the proprietary rights of the seed breeder in the results of his improvements must be conserved as far as possible in a field where patents are impossible. Standardization must not remove incentive for betterment. This, however, is another subject.

Many points may be raised which would seem to indicate the futility of studies such as we have under consideration. The delicate shading between characters, the speedy changes in types from

year to year, the difficulty in separating heredity from environmental variations, the existing confusion, and the injection of the commercial interest all tend to discourage. Science, however, refuses to be baffled. Case differences which are unnoticed by the lay observer are obvious to the trained student, so solutions to seemingly "impossible" problems shape themselves as the midst of ignorance gives way to the ordered array of accurate knowledge.

FACTORS INFLUENCING THE ABSCISSION OF FLOWERS AND PARTIALLY DEVELOPED FRUITS OF THE APPLE.

BY A. J. HEINICKE, *Cornell University, Ithaca, N. Y.*

The failure of a large percentage of apple blossoms to set and the heavy loss of partially developed fruits during the June drop is frequently associated with poor pollination and lack of fertilization. That these conditions are responsible is suggested by the fact that the apples which fall during the June drop, or before, usually have fewer seeds to the fruit than those which remain on the tree. The following figures, which are based on apples from a Rhode Island (Greening) tree, are characteristic for other varieties as well:

Average number of seeds in 100 fruits which fell from the tree = 3.51.

Average number of seeds in 100 fruits picked from the tree = 6.35.

Nevertheless, many blossoms set fruit even though they are poorly fertilized, and many apples with few seeds remain on the tree after the June drop. On the other hand, flowers which are cross-pollinated and fruits which contain a relatively large number of seeds are often lost. Such a loss may be caused by diseases, insects, winds, frost, hail, etc., but it occurs even without such destructive agents.

Obviously then, there are other factors in addition to pollination and seed development which prevent the normal abscission of flowers and partially developed fruits. Studies which have been in progress at Cornell during the past three years seem to indicate that the amount of food and water which reaches the individual flowers and fruits determines whether or not they will remain on the tree. If the sap supply is adequate, the flowers set fruit, and the fruits mature, notwithstanding the fact that they may have few seeds.

The purpose of this paper is to present a brief synopsis of the results which led to these conclusions.

RELATION BETWEEN FRUIT-SETTING AND WEIGHT OF NEW SPUR GROWTH.

When the fruit bud opens in spring a short spur varying from 0.3 to 2.0 centimeters in length is produced. This new growth

bears leaves, laterally, and a cluster of flowers terminally. That there is a very definite relation between the weight of this new spur growth and the ability of the spur to bear fruit is shown by the following data:

Average weight of 139 spurs which did not set fruit = 1.45 grams.

Average weight of 112 spurs which did set fruit = 2.76 grams.

These figures are based on a consideration of all flower-bearing spurs obtained from a large Baldwin branch. Similar results were obtained in many other branches.

Spurs which lose all their fruit soon after blooming time do not weigh as much as those which hold fruit until the June drop; the latter, in turn, do not weigh as much as spurs which finally set fruit. The following example based on examination and weights of all spurs on a large Baldwin branch is typical of others:

Average weight of 30 spurs which held fruit less than 2 weeks = 2.94 grams.

Average weight of 28 spurs which held fruit until June drop = 3.29 grams.

Average weight of 30 spurs which held fruit after June drop = 4.27 grams.

Spurs which bear two fruits are usually heavier than those which bear only one fruit. This is illustrated by the figures given below:

Average weight of 60 spurs bearing one fruit = 3.08 grams.

Average weight of 40 spurs bearing two fruits = 3.62 grams.

These spurs were obtained from a large Baldwin branch which produced 100 fruit-bearing spurs.

RELATION BETWEEN FRUIT-SETTING AND LENGTH OF PREVIOUS SEASON'S SPUR GROWTH.

The length of spur growth produced during the season in which the flower bud is formed may vary from a few millimeters to several centimeters. Flowers on spurs which grew more than one centimeter during the previous season are more apt to set than those on spurs which made a short growth. The data obtained from several Baldwin branches which produced a total of 677 flower-bearing spurs in 1916, are typical of other cases.

Number of spurs which made more than 1 cm. growth during 1915 = 320.

Percentage which produced fruit in 1916 = 67.2.

Number of spurs which made less than 1 cm. growth during 1915 = 357.

Percentage which produced fruit in 1916 = 25.5.

The weight of the new spur growth and the length of the previous season's growth are closely related as shown by the data below:

Average weight of 229 spurs making more than 1 cm. growth during the previous season = 2.84 grams.

Average weight of 261 spurs making less than 1 cm. growth during the previous season = 1.34 grams.

These figures are based on a consideration of all spurs found on several branches of a Baldwin tree. The same relations prevail in other varieties.*

RELATION BETWEEN FRUIT-SETTING AND THE NUMBER OF FLOWERS TO THE SPUR.

The number of flowers in a cluster may vary from 2 to 8. The spurs which produce many flowers are more apt to set fruit than those which produce few flowers. This is shown by data similar to the following:

Average number of flowers on 151 spurs which lost all fruit within 2 weeks after blooming = 4.45.

Average number of flowers on 223 spurs which held fruit until the June drop = 5.02.

Average number of flowers on 134 spurs which finally set fruit = 5.74.

These figures are based on examination of all flower-bearing spurs from several Baldwin branches.

In several cases all the spurs from a given branch were classified according to the number of flowers they produced. The percentage of spurs which bore fruit was determined in each case. Typical figures based on a consideration of all spurs on several Baldwin branches are given below:

Number of spurs with 4 flowers = 50; percentage set = 20.0.

Number of spurs with 5 flowers = 137; percentage set = 40.9.

Number of spurs with 6 flowers = 256; percentage set = 54.9.

That a higher percentage of the many flowered spurs are fruitful may be due to the fact that such spurs could afford to lose four flowers each and still have one or two left to set fruit. This, however, is not the case as shown by the following figures where the percentages are based on the flowers rather than on the spurs:

* In Bul. 129 of the Oregon Expt. Sta. which has just been received, Yeager likewise reports a correlation between the amount of growth that a spur made one year and its production the following year.

56.7 per cent of the flowers on 25 spurs with 4 flowers set fruit.

60 per cent of the flowers on 16 spurs with 5 flowers set fruit.

72.5 per cent of the flowers on 17 spurs with 6 flowers set fruit.

These data are based on an examination of all flower-bearing spurs obtained from a Baldwin branch.

The number of flowers borne on a spur is correlated with the weight of the new spur growth. This may be seen from the following example :

Average weight of all spurs which produced 4 flowers = 1.76 grams.

Average weight of all spurs which produced 5 flowers = 2.73 grams.

Average weight of all spurs which produced 6 flowers = 3.36 grams.

The flower-bearing spurs in this case were obtained from a Fallawater branch. Similar figures have been secured with other varieties.

RELATION BETWEEN WEIGHT OF NEW SPUR GROWTH, DIAMETER OF CONDUCTING TISSUE AND SET OF FRUIT.

The diameters of conducting tissues of the spur, measured just below the terminal bud, vary from 1.0 to 2.5 millimeters. The relation between the diameter of the conducting tissue and the weight of the new spur growth is shown by the following representative figures.

Average weight of 74 spurs with a small conducting tissue (1.-1.4 mm.) = 1.50 grams.

Average weight of 112 spurs with a medium conducting tissue (1.5-1.9 mm.) = 2.47 grams.

Average weight of 39 spurs with a large conducting tissue (2.0-2.5 mm.) = 3.27 grams.

These data are based on a consideration of all spurs obtained from a branch of a Baldwin tree.

Obviously, more sap can pass through the large conducting tissues. Therefore, the flowers and fruits produced on heavy spurs will be most abundantly supplied with sap. The fact that the heavy spurs, which have the large conducting tissues, produce more fruit than lighter spurs, suggests the possibility that an inadequate supply of sap may cause the abscission of fruits from the small spurs. That the water supply does influence the set is indicated by other observations, a few of which will be presented at this time.

RELATION BETWEEN FRUIT-SETTING AND THE WEIGHT OF LATERAL GROWTH FROM THE FLOWER-BEARING SPUR.

The amount of growth which is produced from a lateral bud of the flower-bearing spur varies from a few millimeters to ten or more centimeters. Some spurs fail to make any lateral growth whatever, during the year they bear flowers. Spurs which produce much lateral growth are more likely to set fruit than those which produce little growth. This fact is indicated by the following example, which is based on a study of all spurs of a Baldwin branch:

Average weight of lateral growth produced by 42 spurs which lost all fruit = 0.79 grams.

Average weight of lateral growth produced by 52 spurs which held their fruit = 1.35 grams.

The amount of lateral growth produced by a spur is dependent upon the sap supply, as will be shown later. Other things being equal, the greater the water supply the more growth produced.

RELATION BETWEEN FRUIT-SETTING AND THE AMOUNT OF BLOOM.

It frequently happens that similar branches on the same tree produce varying numbers of flower-bearing spurs. As a rule, the limbs with a heavy bloom produce fewer fruits to the spur than limbs equally large and similarly located, but which have a light bloom. The following example is typical of others:

Number of flower-bearing spurs on a limb with a light bloom = 52; percentage setting fruit = 76.9.

Number of flower-bearing spurs on a limb with a heavy bloom = 116; percentage setting fruit = 16.2.

These data are based on two equally large Baldwin branches obtained from the same part of the tree.

As a rule, the branches with many flowers have smaller leaves than those with few flowers. Experiments seem to indicate that the size of the leaves is influenced by the water supply during the time the leaves are making active growth. Other things being equal, the greater the supply of water, the larger the leaves.

It has been shown that the weight of the spurs and the diameter of the conducting tissues are closely correlated. The larger spurs have the better water supply. In this connection, it may be of interest to point out that spurs with a conducting tissue of a given diameter from branches which produce many flowers are not as heavy as spurs with tissues of the same diameter, from branches which produce few flowers. The following data based on material from a Baldwin tree will serve to illustrate this fact:

Diameter of Conducting Tissue of Spurs.	Spurs from Limbs with heavy bloom.		Spurs from Limbs with a light bloom.	
	No.	Avg. Wt.	No.	Avg. Wt.
1.0-1.4 mm.	49	1.50 grams.	7	2.06 grams.
1.5-1.9 mm.	56	2.37 grams.	34	3.09 grams.
2.0-2.5 mm.	20	3.10 grams.	14	4.01 grams.

It should be noted that the percentage of weak spurs is greater on the branches with heavy blooms. This, in itself, may account for a part of the great loss of flowers and fruits from such branches.

EXPERIMENTS TO DETERMINE THE RELATION BETWEEN FRUIT-SETTING AND SAP SUPPLY.

Pairs of large limbs, which were approximately five centimeters in diameter at their bases and which had equally heavy blooms, were selected. The members of such pairs either formed the arms of a "Y," or they arose within a foot of each other from the same parent branch.

One of the limbs was sawed half way through near its base, the other was left as a check. The object of sawing was to reduce the supply of sap. This was done when the flowers appeared in the spring. Typical results obtained with several Baldwin branches are given below:

Total number of spurs on untreated branches
= 454; percentage producing fruit = 48.2.

Total number of spurs on sawed limbs = 517; percentage producing fruit = 31.9.

In other cases the sap supply to the individual spurs was increased. One of the limbs of a pair was severely pruned, the other was left unpruned. In pruning, care was taken to remove entire branches rather than head back new growth. The weaker spurs only would have been removed in the latter case. The pruning was done in spring when the flowers opened. The results secured in such experiments are represented by the following data:

Number of spurs on unpruned limb = 682; percentage producing fruit = 20.4.

Number of spurs on pruned limb = 350; percentage producing fruit = 37.4.

The range or variation in the percentage of spurs which set on similar untreated limbs which form members of a pair is indicated by the following figures:

Number of spurs on limb A = 1064; percentage producing fruit = 22.0.

Number of spurs on limb B = 1155; percentage producing fruit = 22.2.

That the pruning has actually increased the amount of sap available for each spur is shown by the following analysis of the lateral growth produced by spurs from pruned and from unpruned branches:

Average weight of lateral growth from 50 of the largest spurs from pruned branches = 2.68 grams.

Average weight of lateral growth from 50 of the largest spurs from unpruned branches = 1.90 grams.

RELATION BETWEEN VIGOR OF SPUR, SEED VALUE, AND SETTING OF FRUIT.

The facts which have been presented thus far indicate that vigorous spurs are more apt to set fruit than weak spurs. As compared to weak spurs the new growth of vigorous spurs is heavier, the number of flowers to the spur is larger, the diameter of the conducting tissue is longer, and the weight of the lateral spur growth is greater, all of which indicates that the food and water supply is more abundant on vigorous than on weak spurs. It seems reasonable, therefore, to assume that flowers and fruits on vigorous spurs can obtain the food and water required for their development more readily than those on weak spurs. Hence, the former do not lose as many fruits as the latter.

But the fact remains that weak spurs do bear fruit. If the sap supply is the basic factor in determining the set of fruit, then there must be some means of overcoming the handicap of inadequate food storage and small conducting tissues which are found in weak spurs. Pollination and seed development are such means.

Seeds in a fruit apparently serve as a suction pump. The more seeds the greater the suction. A relatively small suction is required to secure sufficient sap on vigorous spurs. Apples produced on such spurs can develop even though they have few seeds. A greater suction is required to secure sap on weak spurs. Hence, only those fruits having a high seed value will remain on such spurs—fruits with a low seed value drop.

If this be true, the average weight of spurs which bear fruits with a high seed value should be less than the average weight of spurs bearing fruit with a low seed value. The data below, which are based on a consideration of all spurs from branches of several varieties, show that such relations do exist:

Average weight of 278 spurs which bear fruit with a low seed value = 3.41 grams.

Average weight of 197 spurs which bear fruit with a high seed value = 2.90 grams.

The spurs bearing fruits with a low seed value are 17.6 per cent heavier than those bearing fruits with a high seed value.

We are interested primarily in the smaller spurs of each lot. If we consider such spurs only, the relation between seed value, vigor of spur, and set, will be more clearly shown.

In the following figures only one-half of the total number of spurs, that half containing the smaller spurs, is considered:

Average weight of 138 smaller spurs which bear fruit with a low seed value = 2.65 grams.

Average weight of 99 smaller spurs which bear fruit with a high seed value = 2.07 grams.

In this case the spurs bearing fruits with a low seed value are 28 per cent heavier than those bearing fruits with many seeds. The weaker spurs lost the fruits with a low seed value. *Vigorous spurs, however, retained such fruits.*

The term, "seed value" is used advisedly. The mere number of seeds is not a reliable guide to the quality, or the value of seeds as a pump. Such value is associated with the size and weight of the embryo, as well as other factors. In general, it may be said, that seeds resulting from cross-pollination will have a higher value than those produced by self-fertilization.

OBSERVATIONS CONCERNING THE PHYSIOLOGICAL EFFECT OF SEEDS.

The following observations indicate that seeds actually do exert a pull or a suction:

1. The size of the fruit varies with the number of seeds, provided the apples in question are borne under similar conditions on spurs of equal vigor. The weights of fruits produced on equally vigorous spurs on a Fallawater branch will illustrate this fact.

Weight of Spur.	Number of Seeds.	Weight of Fruit.
2.28 grams	3	16.84 grams.
2.24 "	5	18.72 "
2.21 "	8	23.15 "
2.26 "	9	24.02 "
2.22 "	11	29.40 "

This same relation holds in other varieties.

2. A large number of the apples which fall during the June drop are one-sided. The side containing seeds is larger than the side without seeds. Most of these fruits came from weak spurs, and the sap which they did obtain was gotten under difficulty, hence, it was confined largely to the side with seeds.

3. Professor W. H. Chandler* has shown that leaves tend to withdraw moisture from the fruit. The leaves on detached spurs with leaves and fruit will remain turgid for several days. The

* Chandler, W. H.—*Sap Studies with Horticultural Plants.* Missouri Agr. Expt. Sta. Research Bul. 14 (1914).

fruits, on the other hand, shrivel, due to loss of water. Observations by the writer have shown that the many seeded fruits lose their water more slowly than few seeded fruits. For this reason the leaves on spurs bearing many seeded fruits dry up, while those on spurs with few seeded apples remain turgid. Furthermore, if water is withdrawn from few seeded fruits, the seedless side often shrivels before the side with seeds.

4. That the leaves generally show a higher osmotic pressure than green fruit has also been shown by Professor W. H. Chandler. A few determinations of the freezing points of saps expressed from fruits with a high seed value and from those with a low seed value indicate that the former have a greater osmotic pressure. Representative data are given below :

Depression of the freezing point of saps from fruits
with an average of 3 seeds = 0.952° C.

Depression of the freezing point of saps from fruits
with an average of 6.2 seeds = 1.033° C.

These figures are based on a determination of saps from six lots of fruit in each case.

The results which have been presented emphasize the importance of the vigor of the individual spur as a factor in fruit-setting. Under many conditions cultivation, especially early cultivation, spring applications of a quick acting nitrogenous fertilizer, and moderate pruning, favor the production of vigorous spurs on old trees. Some varieties do not produce vigorous spurs because the climatic and soil conditions are unfavorable. Cross-pollination is the only remedy for such varieties. Cross-pollination is also relatively important in those cases where self-fertile trees are grown in sod, or under other unfavorable conditions.

HORTICULTURE AS A SCIENCE AND AS AN ART.

BY M. A. BLAKE, *Rutgers College, New Brunswick, N. J.*

It seems appropriate at this stage of horticultural progress in America to observe the relations existing between horticulture as a science and as an art.

Science relates to laws and principles, while art signifies skill in practice.

At the beginning of the nineteenth century, horticulture was largely art unsupported by science even in England. The importance of science in fruit culture, however, was appreciated and recognized by some of the writers of that period. Joseph Hayward, in 1818, has much to say about horticulture as a science and as an art. In fact, his book is entitled "The Science of Horticulture Including a Practical System for the Management of Fruit Trees." The text of the book is confined to a discussion of matters pertaining to fruit trees so the term horticulture is used by Hayward in a restricted sense.

Some statements that appear in his book will enable us to form a clear idea of the state of horticultural science at that period. In the introductory pages we may first note the following:*

"Ten years since I was flattered in the success of my experiments and improvements, and felt convinced of the possibility of reducing that, which was in its general practice no more than an uncertain and mysterious art, to a clear and delightful Science; but I had not the vanity to believe I was myself equal to the arduous task."

Hayward also calls attention to the marked prejudice against books as a means of acquiring knowledge of the art of fruit culture. We may read further in the introductory pages.†

"The difficulty of acquiring a knowledge of training and managing Fruit Trees from Books, has been remarked and deplored by all the different writers on the subject, to whom I have thought it necessary to refer in the course of my work; viz:—Bradley, Miller, Hitt, Forsyth, Mr. Knight and the Encyclopedia Britannica; and although this insufficiency has been thus early and generally noticed, the present state of the Art proves how little has been done to remedy the defect. Without a correct knowledge of the Cause, no one can possibly be certain of success in producing or removing an Effect."

He continues as follows upon page twelve of the introduction:

"Perhaps nothing can more clearly evince the imperfect state of Horticulture, or afford a more substantial proof of the absence of scientific principles in its general practice (at any rate of that part which forms the peculiar subject of the present work), than this general opinion, that a correct knowledge of the Art of Gardening cannot be obtained from theoretical writings.

"When, indeed, any art rests upon a bare mechanical movement grounded on the casual and contracted observation of effect only, it must be impossible to diffuse a general knowledge of it by writing."

Hayward calls attention in no uncertain way to the lack of scientific knowledge of fruit culture in England in the early part of the nineteenth century, and to the fact that the books of the time were largely the expression of unproven theories.

Yet, fine specimens of fruit, vegetables and flowers were produced by the gardener's art in England and upon the continent long before the appearance of Hayward's book.

William Coxe writing in America at this same period does not complain of the lack of science in fruit culture, but does emphasize the necessity for an understanding of some of principles of chemistry in the successful manufacture of cider.

The sciences have made wonderful progress during the past century. Investigation and research has been promoted by private enterprise, by State and by Nation. The science of horticulture has developed until it is sometimes allowed to overshadow the art. Not that the art has failed to make progress also, far from it. We can call to mind seeing immense fields of lettuce or cabbage or some

* Prefatory Explanations and Remarks, Page VIII.

† Prefatory Explanations and Remarks, Page IX and X.

other vegetable where one specimen is almost as perfect as another. There are orchards containing hundreds of well-formed trees; there are extensive nurseries where the skill of the propagator is demonstrated in thousands of specimens and there are immense greenhouses where successive benches of carnations, roses or chrysanthemums display perfect health and vigor. Innumerable varieties of fruits, vegetables and flowers have appeared that mark great progress in size, beauty and quality.

Science may state the cause of an effect; it may reveal the factors determining size, color and quality of flowers and fruit, but it requires art to produce the results.

A man may be thoroughly acquainted with the principle of a whip-graft, and yet be unable to earn a fair wage at the work.

We recognize these facts in a general way, but do we accord art its full rank. Let us go into the matter in further detail. The same spray material and spray schedule is not infrequently recommended to several apple growers in the same neighborhood. Even if they all spray at the same time and with similar outfits the results will be different. Here and there a grower stands out with exceptional results and he maintains this rank year after year. His neighbor may borrow his spraying outfit, purchase the same kind of spray material and try to duplicate his work to the minutest detail, but there is always a difference in the results.

A florist maintains his position in a commercial establishment, or in a private range by his ability to secure crops of fine flowers. If he fails during the first few months he is frequently discharged. This seems to be rather hasty and severe judgment, but there is a feeling among florists that if there does not appear to be a sympathetic understanding between the grower and his plants and if they do not respond readily to his efforts the best remedy is another man.

I believe that most scientists if asked an expression of opinion would state that if the science of forcing flowers in the greenhouse were better understood it would largely remove the necessity for changing men in this way. I held this opinion myself at one time, but it has been greatly modified in recent years.

Many factors enter into the forcing of flowering plants in a greenhouse. It may appear to be an easier line of effort and less subject to disturbing factors than the culture of out-of-door crops, since the factors of temperature and moisture are under control in the greenhouse, but in reality a much higher degree of art is required for success.

One florist is very successful with a certain variety of rose, while his neighbor discards it as worthless. The former may permit the latter to observe each operation of culture, may allow him to keep records of temperature, humidity and moisture and yet years of effort will not bring the same result. One florist among hundreds really succeeds in the culture of the American Beauty rose. Science may tell us later why the majority fail, yet, I believe we shall still have comparatively few successful growers of this rose. Some plants are like a very finely adjusted machine; if all factors are not per-

fectly harmonized trouble soon develops. This fine adjustment of temperature, ventilation, humidity and other factors is an art.

Science has done much to simplify the culture of many plants and has often changed a mysterious and obscure art into a series of plain laws and their effects, and yet science cannot replace skill in practice. Science without art when applied to the production of horticultural crops is like a locomotive without steam. The machinery is there, but *it* alone does not produce results.

The complaint has been made that graduates of agricultural colleges are not practical, that they are unable to make a creditable showing at first in the art of fruit, vegetable and flower culture. Institutions attempt to overcome this fault by so-called laboratory and field exercises and by assignment to practical work. This problem has been frequently and extensively discussed.

We hear comparatively little about model gardens or model orchards at our state institutions. Most of us consider ourselves fortunate if we have a sufficient area of orchard, garden or greenhouse space where the students may acquire a few ideas as to the practical culture of plants. The college orchard is seldom an example of the art of a skillful fruit grower, but is scarred by the errors of succeeding classes. Is this the best way to impress the student with the importance of art in horticulture?

Many of our young men enter upon research work and here art will demand its place even as in the practical field. The investigator may be called upon to direct the propagation of certain plants for experimental purpose and will meet with delays and serious difficulties if he lacks proficiency in the art of growing plants. Strong plants may not give the same results as weak plants. The success of a test may hinge upon this point alone.

An investigator may so closely confine his efforts to the science of horticulture as to be led astray by some trick of the art. A scientist studying the diseases of greenhouse plants may draw erroneous conclusions unless he is acquainted with the important details of the art of growing the plants.

Plant breeding is an important phase of horticultural development today, and skill in the propagation of seedlings is a necessary feature. Some valuable varieties have undoubtedly been lost in the seed bed, and others, because of lack of skill in culture at some later period.

It is probably true also that some plants of value have been discarded as worthless because the originator failed to provide the proper environment for them, and they responded accordingly.

The college graduate who goes into the horticultural extension service of any state should have a full appreciation of the meaning of the art of horticulture. His duties are to encourage practical growers to follow along new lines of effort or to modify old ones and his every word and act will portray his capacity for such leadership.

In our great desire to advance the science let us not neglect the art of horticulture.

INFLUENCE OF NITROGEN IN WESTERN ORCHARDS.

BY C. I. LEWIS, *Experiment Station, Corvallis, Oregon.*

For three years the Oregon Experiment Station in its branches at Hood River and in the Rogue River Valley, has been conducting experiments with nitrogen.

We find in some of the valleys, trees while relatively young, being from eleven to twenty-five years of age, are nevertheless in a devitalized condition. These trees show a thin, yellow foliage, feeble, sickly growth, and a very early maturity. They produce fruit which tends to be small, and they have a tendency to shed a large percentage of their fruit. We also find the trees and fruit afflicted with various physiological or functional troubles, such as core rot, bitter pit, little leaf, dieback, winter kill, etc.

Chemical analysis of the light soils of the Pacific Northwest has shown them to have a relatively low nitrogen content and at the same time naturally to be deficient in the supply of organic matter.

In order to try and restore these orchards to their normal condition, experiments were conducted with nitrate of soda, the idea being to try and stimulate the trees and restore them, first, by the use of fertilizer strong in nitrogen and, second, to see if it was possible to maintain them in this condition through a modification of cultural methods. Table I shows the results in three years' work in two of these orchards.

It is noted in this table that nitrogen was applied in three ways: (1) dry crystals spread broadcast on the ground, (2) liquid containing the nitrogen poured on the ground, and (3) trees sprayed with liquid containing the nitrogen.

The results the first year seemed to indicate that the best method was to spray the trees, or else to pour the nitrogen in liquid form on the ground. These striking results were secured partly, however, because we did not apply the nitrogen in dry form as early as in the other two cases, owing to a scarcity of material. Another factor was an excessively dry spring, as results in the fall indicated that the dry crystals applied early in the spring did not begin to do their work until the fall rains dissolved the nitrogen.

In the second and third years the nitrogen was applied in all three ways on the same date and seemingly there was very little difference between the methods in which the nitrogen was applied. The nitrogen in these experiments was applied about a month before the trees blossomed, which seems essential if one secures the best results. Possibly some explanation is necessary as to why the two plots receiving no fertilizer did so much better in 1916 than in the former two years. This is due partly to the fact that the orchard had been resting and not doing anything and, second, partly to the fact that these orchards this year are receiving the benefit of shade crops.

TABLE I.

TABLE I.—SHOWS FOR THREE YEARS THE AMOUNT OF NITRATE OF SODA USED PER TREE, YIELD PER TREE IN BOXES, AND AVERAGE ANNUAL TERMINAL GROWTH IN INCHES.

No. Orchard	No. Plat	Nitrate of Soda Pounds per Tree.		Culture	Yields Loose Boxes.			Average Annual Terminal Growth, Inches.		
		1914	1915		1914	1915	1916	1914	1915	1916
1	1A	5.2	5.2	Clover for	4.1	8.1	13	8.4	15.2	20.1
	2B	5.2	5.2	Green	1	8.5	14.8	7.8	11.4	17.1
	3C	5.2	5.2	Manure	.2	6.00	9.6	5.3	13.9	16.1
	4	0.0	0.0	.....	.2	.31	8.8	3.1	6.9	19.9
2	1A	6.75	6.75	Alfalfa Sod	1.9	10.0	14.8	8.8	8.4	15.4
	2B	6.75	6.75	" "	2.3	9.9	15.5	9.2	10.3	8.4
	3C	6.75	6.75	" "	9.8	10.1	15.7	11.8	10.9	14.7
	4	0.00	0.00	....	2.1	.9	5.7	2.9	6.6	5.2

A Fertilizer broadcast on ground.

B Fertilizer sprayed on ground as liquid.

3 Fertilizer sprayed on ground and tree as liquid.

It is interesting to note, however, that by the use of nitrogen in these orchards the yields increased on the average of about ten-fold, and that for general orchard use, applying the crystals dry is sufficient.

This past season we took in addition a new orchard which was run down. We tried in this orchard to determine the value of different amounts of nitrogen. Table II shows the results.

Table II shows variety used, pounds nitrate of soda used per tree, terminal growth in inches, length and width of leaf growth, yield in boxes per tree, and per cent increase of yield.

TABLE II.

TABLE II.—SHOWS VARIETY USED, POUNDS NITRATE OF SODA USED PER TREE, TERMINAL GROWTH IN INCHES, LENGTH AND WIDTH OF LEAF GROWTH, YIELD IN BOXES PER TREE, AND PER CENT INCREASE OF YIELD.

Variety.	Plat.	Pounds Nitrate of Soda per Tree.	Terminal Growth Inches.	Leaf Growth Inches.		Yields per Tree Loose Boxes.	Per cent Increase of Yield.
				Length.	Width.		
Esopus (Spitzenburg)	1	7.3	11.7	2.95	1.79	16.1	87
	2	5.00	9.9	2.92	1.90	13.44	56
	3	Check	4.1	1.99	1.35	8.56	..
	4	3.00	14.1	2.90	1.85	12.61	47
Yellow Newtown	1	7.3	9.5	2.93	1.92	14.1	166
	2	5.00	6.2	2.79	1.82	11.9	124
	3	Check	4.5	2.32	1.48	5.3	..
	4	3.00	6.4	2.75	1.93	9.5	79

This table shows strikingly that there is a very close correlation between the amount of nitrogen applied and the yield procured with each variety.

Perhaps the most striking results were secured in the first orchard mentioned in the percentage of set and in the influence on size of fruit. Table III shows these results.

TABLE III.

TABLE III.—PER CENT OF SET AND SIZE OF FRUIT INFLUENCED BY NITROGEN.
HOOD RIVER EXPERIMENT STATION.

Plat	Pounds per Tree	Fruit Set. Per cent		Size of Fruit. Per cent		
		June 4	Sept. 30	175-150 per Box	138-112 per Box	100 Larger per Box
1	6.7A	82.6	34.6	8.28	24.71	68.10
2	6.7B	68.0	30.7	22.64	29.13	48.23
3	6.7C	69.6	37.3	24.61	41.87	24.61
4	Check	35.3	16.4	76.24	18.32	5.43
Average of fertilized plats....		73.4	34.2	18.51	31.90	46.98
Difference due to fertilizer....		38.1+	17.8+	57.73—	13.58+	41.55+

Concerning the percentage of set, the facts are that there were many blossoms too weak to set fruit on trees that were not stimulated. Nitrogen gave a sufficient stimulus to modify the character of blossom and to influence the percentage of blossoms that were able to set and mature fruit. Nitrogen influenced the size of individual specimens remarkably. In some cases it made the fruit too large. The color was not quite as good from the use of nitrogen as otherwise, but it was a brighter, more lively color. One could have thrown away the poorer colored and over-sized specimens and still have a tremendous increase in high grade commercial fruit. Not only that, but the average price per box for the apples that had been stimulated by nitrogen would be much greater than from the check. In a commercial orchard of thirty-eight acres, at Hood River, this past spring nitrogen from five to six pounds was applied per tree. The crop this year was 23,000 boxes. Last year it was 1,500 boxes and the year before 4,500 boxes. The change in the vigor of the trees was as remarkable as the increase in yields. At the Rogue River Experiment Station in Southern Oregon, we likewise received very satisfactory results with apples on light soils. Nitrate of soda increased the yields about 7 to 1. With peaches wherever we secured fruit at the rate of 36 boxes on the nitrate plots, we secured only 7 to 9 boxes on the checks where no fertilizer was used. One of the most striking observations made in the Rogue River experiments was that in both apple and peach fertilized plots there was less frost damage than in unfertilized plots, the nitrogen seemingly producing blossoms stronger and more resistant to frost.

CONCLUSIONS.

Nitrogen is apt to be the deficient factor in the light soils of the Pacific Coast. This can be most quickly and easily applied

in the form of nitrate of soda. From three to seven pounds per tree should be spread broadcast about a month before the trees bloom. For permanent improvement where irrigation is possible, shade crops should be planted, and where irrigation is not possible, cover crops. Our experience shows that nitrogen should be applied at least a month to three months earlier than has generally been recommended in the past; that nitrate of soda exerts a much longer influence than formerly supposed: that food and moisture exert a tremendous influence on the trees very early in the season before they bloom: that adding nitrogen and organic matter to the soil tends to overcome most of the functional troubles: that nitrogen can be made a distinct aid to successful pollination and set of fruit: that frost damage in some cases is less where sufficient nitrogen is employed: and lastly, that the application of nitrogen can be easily overdone.

REPORT OF THE COMMITTEE ON RESEARCH AND EXPERIMENTATION.

(This report is divided into four parts as follows:)

(PART I)

By L. H. BAILEY, *Chairman, Ithaca, N. Y.*

At the Columbus meeting there was appointed a Committee on Research and Experimentation, to report at the succeeding meeting. I was not present at the time and do not know the special reason for the appointing of the committee; but the secretary defined its purpose "to outline and give methods of the best ways of attacking research and experimental problems." I conceive that it was not the intention to make a review of experiment station literature touching horticulture, or to sit in judgment on any piece of work, or to elevate the present output, but rather to provide definitions and to develop points of view, with practical suggestions on ways of organizing any proposed line of investigation.

The members of the committee of five could not come together, inasmuch as two are in California, one in Canada, and two in New York. Only by correspondence could the subject be covered and then only in a most general way, for it requires close personal conference to secure agreement on methods of procedure. The first passage of letters resulted in a statement of four general problems or subjects to be considered, and these subjects were assigned to those who suggested them. The chairman was undoubtedly at fault in not assigning these subjects earlier; yet two members of the committee were able to submit statements. As these statements have not been discussed by the committee as a whole and as we have been unable to secure a meeting (only two members being here present), I have thought it unwise to sub-

mit a report as coming from the committee, but to present the statements of Dr. Webber and Dr. Howard and to make an informal statement of my own; these then stand as three papers on the subject of research and experiment in horticulture.*

At least four subjects or lines of discussion are to be considered in any adequate treatment of this field: definitions of research, experiment, tests and investigation, with indications of the ranges they cover; statement of the fundamental training required for the successful undertaking of research; how to lay out an experiment or line of research; the way in which the facts shall be marshalled, assorted, compared, judged, to bring out the essential facts in any piece of research.

The statement of Dr. Howard ably and graphically defines the field. It is evident that an experiment may not be research, but only one stage or part in it; if continued, and particularly if so designed and carried through as to cover a subject adequately in respect to the underlying reasons, it may be practically synonymous with research. A test is a still smaller or more temporary undertaking than an experiment: one may test a series of varieties, the effect of a fertilizer, a reaction in a test-tube or retort, or make other trials. The word "investigation" is generic in its character, and covers many of these distinctions. The word "demonstration," as now employed by the colleges, experiment stations, and farm bureaus, is a name for a local teaching enterprise.

The measure of research lies largely in its intention, and the intention is to discover the underlying fact or a law of wide application. To undertake research, one needs not only the equipment but also to consider the element of time,—time to get all the facts in hand, to study them and compare them and challenge them, and to verify them. The final result should be stated in terms of the particular research, not translated into commercial values: these commercial values, if made, should be a separate computation and should not be the measure of the research itself. Application is not necessarily a part of research.

The purpose of research is to discover and to express the truth. The research value does not depend on the name of the investigation, on its size or extent, on the authorities cited, or on the bulk of the publication.

As to preparation for research, the investigator should be a student in all that the word implies, and have the general equipment of a scholar. He should have the intellectual tools of his horticultural profession, such as good grounding in physics, chemistry and physiology resting on thorough understanding of the common and corollary branches. These subjects are important also not only as tools, but as training in methods and ways of approach. He should have good chemistry, physics and physiology and then more chemistry, physics and physiology. The investigator should have the contemplative or reflective habit or pose, for the results

* Since the meeting was held Prof. Macoun has submitted the fourth paper of the report of this committee.

do not come quickly, by snap judgment, or by what is called "brilliance." He must continue his study.

No college course can provide this complete preparation. I have never known an investigator who thought himself sufficiently prepared for his task. Much of his preparation he must gain as he goes. He must fit himself, by new preparation, for each new piece of work; he studies it before he begins it, and considers its bearings and relationships.

In addition to the technical education in the underlying and correlating sciences, the investigator needs, as I see the problem, to have good training in English, that he may make sharp distinctions in words and give a clear and unequivocal expression to his results, for he has a right to be understood only in the language that he uses; sound training in logic, as a good lawyer has it, that he may weigh his evidence with precision; careful work in systematic botany not only for its own discriminations, but also for its drill in dichotomy whereby equals and not unequals are compared.

As to the organizing of research, I am much impressed by the clear distinction that Dr. Webber makes between what may be considered the piece of work that concerns or issues from one investigator or at most from one subject-matter department, and that which is inter-related between different persons and departments and is really the expression of the institution as a whole. In the former class, the one worker himself or the head of one department, is directly responsible and should have headway. In the second class, there must be careful coordination by a directing authority, to the end that the research may be properly solidified and subdivided, with the necessary cohesion and authority. In institutional problems or lines of investigation, the individual worker may be free in his own subject-matter, but he is to recognize himself as a part of a whole, that he is working only on a piece of a problem. In such kinds of investigation I am afraid that there is danger of too much separateness and independence among the men, too much inequality of enterprise, and too great diffusion of responsibility. Always do I stand for both individuality and freedom, but the best individuality is often assured when the person is a part of a good program; when this program represents an institution as a whole, there must be a responsible single authority behind it.

I am glad that the American Society for Horticultural Science is considering these questions. They are fundamental to any permanent work in the subjects to which you have elected to devote your lives. I suggest that you have a standing cohesive committee of say three persons who could report to you from time to time on the tendencies in research, on important happenings, and to keep you in line with the best thought on the subject. I wish that one member might be chosen from outside the horticultural field. The committee would exercise no censorship and have no control over the work of the members; and yet I can conceive that different members might be glad to ask its advice on subjects of research that they have in mind.

(RESEARCH AND EXPERIMENTATION, PART II)

Definitions of Research, Experiment Tests and Investigation.

BY W. L. HOWARD, *University Farm, Davis, California.*

Primarily, experimentation consists of one or more experiments, trials or tests—little excursions into the unknown—which may result in simple discoveries, in the same sense that an adventurous traveler in an unexplored country may discover a new river, lake or mountain. Research is the discovery, or attempted discovery, of new truths or fundamental principles. A discovery of a fact as the result of an experiment or test may be of considerable local importance, while the discovery of a general truth of principle may have a very wide or even universal application.

The aborigines of America undoubtedly discovered many important rivers, lakes and mountains but such discoveries meant little to them beyond possible new hunting grounds and new enemies to fight, and contributed nothing at all to civilization or its betterment of humanity. How different the discoveries of Lewis and Clark, La Salle and Pere Marquette! These hardy pioneers had something more in view than the mere finding of rivers; they sought outlets, gateways to their own or other countries which might be an aid to settlement and commerce. To them the mere finding or exploring of a river was a means to an end. To General Fremont the encountering of herds of buffalo was a mere incident in his western march of discovery, while to the Indians this alone would have been entirely sufficient.

Journeys into the unknown, even when pursued in a definite direction and for a particular purpose, both in an experimental and a research spirit, may lead to more important results than are anticipated. Columbus on his famous western voyage had little idea of discovering a continent, and doubtless Waite was equally surprised when he discovered the fact of self-sterility in pears. Columbus died in ignorance of his "find" while Waite was fully alive to the importance of his chance discovery.

On the other hand a worker may engage in pure research, know what he is aiming at, actually pursue his problem to completion and establish some great truth or principle and yet not realize its importance or application. He is content because his is the pure, highly refined research mind which seeks no reward beyond the satisfaction of having done his work well. Such a man was Gregor Mendel who, like the great Columbus, lived out the remainder of his life and died without knowing that he had builded better than he knew.

The older type of research man—and his kind is by no means extinct yet—maintained that to be true to his calling he must devote his time and energies to the faithful pursuit of a principle and was concerned not at all as to whether the truth or principle might have some useful application. This same spirit domi-

nated our older educators who believed that the aim of all education was culture undefiled by thoughts of its possible application to such mundane problems as bread and butter getting. Both of these ideas serve the very useful purpose of establishing high ideals but happily we now know that, as all education, whether it be classical, professional, technical or even vocational, has a cultural value, that research is no less pure and commendable because its aim is to serve some industrial need. And by this I do not mean to belittle the ideals and work of our numerous research men in the pure sciences.

Our great danger as we face so many pressing agricultural problems lies in the fact that a goodly sized army of experiment station men are inclined to take a wild leap from the old fashioned habit of experimentation to the more alluring field of research and every man wants to get there first. This makes it necessary for us to remember that experimentation is just as commendable as it ever was, provided we recognize its limitations. The Adams Act has glorified the term research by focusing attention upon it. This Act has also established certain standards as to what constitutes research, which has been a great help to experiment station workers in classifying their problems. Without mentioning names or institutions, Dr. True has told me of the difficulties he encountered in connection with his duties of selecting and approving Adams fund projects. In brief, many were submitted while few were approved. In some states he had little trouble, while in others the difficulties encountered were great indeed. In many instances there seemed to be almost a complete misunderstanding as to what constituted research and oftentimes high administrative officials were the hardest to make understand. Small wonder then that young men receiving their bachelor's degrees five or ten years ago—or later—have difficulty in comprehending the difference between research and experimentation.

In order to make my conception clear as to what constitutes research and what experimentation, I wish I might discuss concrete examples in recent horticultural station literature, but that would be much too personal and doubtless would lead to endless controversy. I shall, then, have to be content with citing semi-hypothetical cases. But a few observations by way of preface may make my task easier: A man may take a walk without intending or, in fact without actually going anywhere in particular. He may have the definite aim in mind of trying to walk off a headache or improving his digestion and may succeed in both. On the other hand he may start to walk to the village of Jonesville or Podunk—something definite—or to find the family cow that has strayed away, or to search for some rare wild-flower, things equally definite. In the first instance the walk might be likened to a simple experiment while the others are more in the nature of research. In both cases walking had to be done, but the aims and objects of the latter might encompass or include the former, both as to the actual walking and its results.

A simple experiment may be performed and actually answer the question involved and may stop there. Also in answering the question, another question may be raised which may require another experiment or test. This in turn may be similarly tested and decided when others may arise and so on, but all such tests remain in the category of experiments. During the course of the experiments, however, the experimenter may come to the conclusion that there is some hidden reason at the bottom of all his tests which may explain why he has been getting certain results—something that will clear up the whole situation. Long after the practice of medicine was rated as a science, physicians were familiar with the fact that the human heart pulsated, that there was a difference in color of the blood of the veins and arteries, that blood-poisoning might start in a man's little finger and quickly involve the hand, arm and body and result in death, and doubtless many, many experiments were performed in connection with these phenomena which developed the fact that the heart beats seemed to synchronize with the red flood gushing from a broken artery, that septemia starting in a remote part of the body always traveled towards the heart, etc., etc., but the more or less isolated facts pertaining to these various things usually meant little until Harvey's researches supplied the fundamental principle underlying all by the discovery of the circulation of the blood.

Pollination studies may be carried on with a certain fruit; experiments are performed consisting of the land-pollination of this fruit with its own pollen and with foreign pollen, the usual precautions being taken with regard to the purity and vitality of pollen used in order that the final results may be properly interpreted. The tests show that the fruit is not only self-sterile, but that a certain two varieties are good pollinators for it and that two others are not. The next year other similar experiments are performed which develop the fact that several of the varieties are self-sterile and that certain ones are inter-sterile, but that a certain few are safe pollinators for many. These facts are very valuable as they enable growers to plant trees with considerable assurance of getting crops, but the experimenter becomes dissatisfied because his experiments have not told him why a certain variety is fertile of self-sterile. He suspects malformations in the flowers which might constitute a physical hindrance to pollination; he also suspects chemical antagonism between the pollen and ovule or that the trouble may be due to certain other physiological causes. The series of experiments is now rapidly becoming an investigation and when a definite program has been mapped out, which has for its object the finding out of the cause or causes which underlie self-fertility or self-sterility in general or for the particular fruit in question, with a logically arranged set of experiments for pursuing the inquiry, the problem develops at once into a genuine piece of research.

A set of pruning experiments might be undertaken. These might include the proper shaping and training of young trees by

making use of various manipulations and later pruning to secure the largest sustained yield of fruit consistent with the health and mechanical strength of the trees. The character of the fruit and the size of the crops produced undoubtedly would be a correct measure of the importance of the different methods of shaping and pruning, and might answer the question or questions which were the objects of the experiment, but the line of work would still remain under the heading of experimentation. However, if some of the pruning is done in summer and it is noticed that the trees seem to react differently to the cutting—that one week new growth starts rather quickly from near the point where the branches have been headed in, while one or two weeks later it may not start, and then starts again following a similar cutting two weeks later still—and becomes interested in these phenomena to the extent of starting an inquiry to try to determine why trees react so differently to cutting or, in other words, to find the specific effect of pruning, the work changes at once from experimentation to research.

It is thus seen that experiments are necessary steps in carrying on research work, but it is also clear that research is much deeper than experimentation. As stated before, experimental tests of various kinds are necessary and perfectly justifiable, and always will be, and more experimental work should be encouraged, but experiments as such should not be confused in their meaning and objects with the scope and ultimate aims of research.

(HOW TO LAY OUT AN EXPERIMENT IN HORTICULTURE, PART III.)

BY H. J. WEBBER, *Citrus Experiment Station, Riverside, California.*

In the segregation of the work of the Committee of Experimentation and Research, there has been assigned to me for discussion the topic, "How to lay out an experiment." Each member of the Society doubtless has very concrete ideas as to how experimental work should be organized and laid out, and it is not to be expected that any one or two methods or rules can be devised that will be generally applicable. There are probably, however, certain general principles which can be stated that may be generally applied.

In all experimentation in agriculture and horticulture the writer believes that the first point for decision is whether the problem is of limited or general nature, or, as I prefer to express it, whether it is to be considered an *individual* or an *institutional* problem. I am, of course, discussing this subject from a state experimental station standpoint, and by these terms I do not mean that certain problems are private and others institutional, but what I do mean is that, as *investigational* work appeals to me, there are certain problems in a station's work that had best be handled by the individual investigator, and certain others that, because of their broad nature and the length of time they must be conducted, con-

cern the entire institution and must be handled by the institution as a whole through committees and the cooperation of various departments.

Let me more clearly outline this by examples. Suppose the problem concerns the causes of sterility or seedlessness in fruits, or the control of peach rust. These examples, I should consider as individual problems. They do not require for their solution, so far as we can see, the planting of extensive areas on the station farm that must be handled uniformly for years and that require the expenditure of extensive funds. They are problems of limited nature, related in each case to one primary science,—in the first instance to genetics and in the second to plant pathology, both of these in turn being parts of the fundamental science of botany. They are not so broad in their nature but that one specialist in the branch indicated should be capable of planning and carrying out a thoroughly satisfactory and trustworthy series of experiments.

A typical, institutional problem is a fertilizer experiment with orchard fruits, such as, oranges or apples, if it is correctly planned and manned. An experiment of this kind requires the permanent assignment to it of a considerable acreage of land. It is an expensive experiment in time and funds. It requires to be planned with the greatest caution and continued for a long series of years, if the maximum results are to be secured. Such an experiment concerns and is of importance to almost all departments of agricultural science. The agricultural chemist is interested from the standpoint of the fertilizers used and their chemical reactions in the soil. The soil physicist is interested in the reactions of the various treatments on the physical characters of the soil, and in turn on the water-absorbing and water-holding capacity of the soil. The soil bacteriologist is interested in the effects on the nitrifying and cellulose-destroying organisms of the soil, and the general effect on all soil organisms. The plant physiologist is interested in the effects on the plants as bearing on the problems of plant nutrition and the modifications of quality by feeding. The pathologists and entomologists are interested in determining whether feeding or fertilization has any effect on vitality that may lessen or increase the susceptibility of the plants to attacks of various fungus and insect pests. The success of the experiment depends in considerable degree in reducing the variability of the different individuals used in the experiment, from inherent heritable causes to such a low deviation that the variation caused by the different treatments is an appreciable and measurable difference known to be the reaction due to the treatment. In this field the services of the plant breeder are required. Lastly, the group of workers interested in orchard management are concerned with the bearing of the findings of this experiment on the problems of practical orchard management.

The above illustrations will clearly indicate what the writer means by individual and institutional problems. The investigator

handling an individual problem should be given the greatest possible scope of freedom in planning and executing his work, and should not be hampered by committee meetings to consider his work and methods. He is a specialist in his field, and his success depends upon his individual initiative and originality. If he fails, it is his failure, and the cause for the failure is easily located. It is not to be assumed that all of the problems connected with an institutional experiment, such as a fertilizer experiment, are of institutional nature and require to be handled as such. In every institutional experiment there will be numerous problems of individual nature that may be carried forward independently by the investigators of the different departments concerned, and these can be handled entirely as individual problems.

The institution experiment, such as the fertilizer experiment suggested, will probably last longer than the university life of the individuals planning it. Every important detail of the experiment must thus be carefully planned and recorded, and no change of treatment made until carefully considered and sanctioned by all concerned. Every record must be clear and full, so that it may be easily interpreted by others not familiar with the details ten or twenty years later. The control of such an experiment is an institutional matter in considerable measure because of the number of departments interested in it.

It would probably be a loss of time to discuss the planning of an individual experiment: it is the planning of the institutional experiment that demands our thought. In general the organization of such experiments can be perfected in two ways: (1) through the work of committees, and (2) by a strong team captain. By the first means the organization of the experiment would be placed with a committee consisting of men representing all lines of science concerned in the experiment, and these men would seek all information available to enable them to lay out the best and most comprehensive experiment. This is the plan of organization I judge that is most commonly pursued. This method, however, has certain dangers. I think it may be safely stated that no general institutional experiment, such as the writer has in mind, can ever be conducted on as large a scale as the investigators desire. Probably the ideal experiment will always be too large and too complex to be feasible of execution. As an illustration, permit me to refer to the planning of the fertilizer, irrigation, and cultivation experiments that are soon to be installed at the Citrus Experiment Station. If all of the comparative treatments that the various investigators are anxious to have included were installed with the necessary number of repetitions and check plats, the entire experimental farm would be utilized for these experiments, and the cost of their maintenance would be prohibitive.

It was first found necessary to determine about what area could be allotted to the experiment, considering other lines of work, funds available, and the like, remembering always that such experiments to be valuable must run for years and must thus be able

to justify themselves and command continuous support. Following this the size and arrangement of the plats, the number of repetitions of each treatment and the number of check plats were decided. All of these factors must be arranged satisfactorily in order that the results when finally obtained will be reliable and have value. These things having been decided, it is evident that only a certain number of different treatments can be made, and the great task is then to determine what treatments are of the most importance, as many important treatments must be eliminated. For over a year the task of planning these experiments has been one of the main lines of work of the Citrus Experiment Station staff, and only the most fundamental things have as yet been decided. The experiments have been limited to an area of about 60 acres. The size, shape and composition of each plat has been determined, as well as the number of repetitions and check plats. The studies of our committee have developed into a veritable research on methods of field experimentation with such long-lived crops as citrus, and would form an interesting appendix to the report of this Committee of the American Society for Horticultural Science.

Coming now to the point, the danger of organizing an experiment by a committee in this way lies in the possibility that the plan finally adopted may be a result of compromise that will be a hodgepodge that after all may be emasculated of its most vital points. The most valuable series of experiments in the history of science are usually those planned to solve certain points. Agricultural experimentation is so new that the best methods of organization are not known.

The second plan of organizing experiments of this nature by what I have termed a strong team captain remains yet to be considered. I have frequently been led to question whether after all the best method may not be to get a strong, virile investigator with originality, vision, and training of the right kind and charge him with the sole responsibility of planning the experiments. Such a man would naturally consult all departments concerned in an experiment and get all the help possible in planning them, but would plan the experiments at least to center on the solution of certain fundamental problems. The result would not be a compromise.

Which of these methods will give the best results is, as yet, a matter of opinion.

In the organization of many investigations of horticultural nature, it is of primary importance to secure the cooperation of men in various special lines. A fertilizer, irrigation, or cultivation experiment, if it is to have its highest value and yield the greatest number of useful lessons, must be studied by chemists, soil physicists, plant physiologists, soil bacteriologists, pathologists, and crop experts. Experiments that cost so much should be used to the maximum extent. Very few experiments of this kind now under way are being so studied. This, I believe, is in large measure due to a failure to recognize what should be individual and what, institutional experiments.

(FUNDAMENTAL TRAINING REQUIRED FOR THE SUCCESSFUL
UNDERTAKING OF RESEARCH, PART IV.)

By W. T. MACOUN, *Central Experiment Farm, Ottawa, Canada.*

As a member of the Committee of Experimentation and Research, I shall but mention a few ways in which, in my judgment, better results could be obtained. In the first place, great care should be exercised in selecting men for experimental and research work, and more particularly the more complicated investigations which could fairly be included in the field of research. A man may be competent to do variety testing in which little concentration of thought is necessary, but when it comes to some problem where many factors are involved, he either has not the ability or lacks the interest to see it through. This brings one to the second important matter namely, the education of the man who has the ability and the interest. Many horticulturists feel the lack of a thorough grounding in the science of chemistry, physics and botany, and the man who is interested in research feels either that without this knowledge it is impossible for him to attack certain problems at all, or else that he is dependent on specialists in these sciences to help him complete his work. Co-operation in research work is desirable, but when, by broad training, it is possible for a man to work the whole problem out himself it is usually much more satisfactory to him and, often, the results are presented in a more convincing way than if several persons had been concerned with them.

The third way in which I believe that better results would be obtained in experimentation and research is by each worker knowing what other workers are doing. Would it not be possible to publish an index in the annual report of the American Society for Horticultural Science of the different lines of experimentation and research in horticulture which are under way at the experiment stations and agricultural colleges in America, to be revived from year to year? Here would, in my judgment, be something that would be invaluable, not only enabling one person to get in touch with someone engaged on a somewhat similar problem to his own, but be a means also of preventing duplication and thus saving much unnecessary waste of time.

REPORT OF COMMITTEE ON GRADUATE COURSES.

By M. J. DORSEY, *Chairman, University Farm, St. Paul, Minn.*

In concluding the report for last year the committee on graduate work suggested lines along which the investigation this year should be made. As many of you will recall, a questionnaire was sent out embodying largely the suggestions made at that time. This report is based almost entirely upon a digest of the replies to

those questions. The general outline of the questionnaire will be evident by following the italicised side heads in the report. These are taken up here in the order they are given in the questionnaire and the discussion under each heading is quite a complete summary of each question as answered.

What is the Best Type of Thesis for the Master's Degree? A digest of the replies showed strongly a sentiment in favor of problems involving originality and developing individual thought and training in methods of attack. Some felt as though they should be of a laboratory or of a technical nature and others expressed the view that they should be field studies, surveys, problems similar to the Hatch fund, one phase of a major station project, studies of marketing, or any problem that would add to the student's knowledge of any branch, technically or commercially. A literary review or a library study of work already done was favored by only two. Some expressed a preference that the problems be practical and some the application of the fundamental sciences to some practical subject. The suggestions as to the field in which the work should be done included chemistry, botany, biology, plant physiology, biometry, genetics, and horticulture. This would appear to give plenty of room. There was little sentiment in favor of requiring in the master's degree only further course work or a literature review; greater emphasis was placed upon fundamental training.

Types of Thesis Required for the Doctor's Degree: The replies showed a general recognition of a distinct difference between the requirements for the master's and doctor's degree. These were expressed in the terms of prerequisites required, scope and high standing of the work and a familiarity with the underlying sciences. The following digest will serve as an index to the views expressed.

As to the type of work, "both field and laboratory research," "strict research," or "more thorough and broader than the master's degree," and "based upon one or more of the fundamental sciences" were typical expressions. One correspondent was in favor of requiring subjects involving "purely scientific investigation of the highest type." The scope of the sciences mentioned as basic for the doctor's degree correspond closely with those for the master's degree. The sentiment as to which were the fundamental sciences underlying horticulture included plant physiology, botany, chemistry, genetics, economics and taxonomy, and the general statement, "fundamental sciences." The statements showed a preference to a relatively narrow problem, carried forward intensively, which led to conclusive results, either negative or positive. One answer stated that the doctor's degree should be to quite an extent "philosophical subjects requiring thorough analyses and comparisons." Another stated "that the doctor's degree should be strictly research confined to fundamental principles. Sufficient time should be allowed to complete the problem undertaken. The standards cannot be made too high. No literature or

biographical work should be accepted. It need not be confined to the laboratory, but may be carried into field, orchard, or packing house, depending on the nature of the work. An age and experience standard should be set."

In this connection should be mentioned that there is an admirable frankness shown on the part of a number of institutions regarding graduate work. The sentiment that the undergraduate work should be developed first was expressed by a number. Others stated frankly that they recommended that their students take their advanced degree in a different institution from their baccalaureate. It would seem from the replies that the distinction between the two degrees is for the most part well recognized and that the type of training recommended speaks well for the conception of what horticulture is to be in the future, as well as indicating largely the type of training the workers shall have in that field.

Suggestions as to the Scope of the Thesis: The replies received to this question expressed a preference for a restricted intensive thesis investigation. Something of the idea is expressed in the following sentences which are quotations. A problem narrow in scope, giving a student a thorough training in directness and accuracy of method. A problem of limited scope with an intensive effort on the part of the student, the subject making little difference. Another, however, expressed a preference for a broad phase of the field of production, marketing, storing, or the preparation of products for storage. The work should be carried far enough to furnish a "fair" basis for conclusions. "As to the scope for the work for the doctor's degree, my feeling is that the problem should be of a very limited nature so that it is possible for a student to cover the field in a thorough way. A broad general subject should be strictly avoided." "The thesis should be of such a nature and scope as to teach the candidate the proper method of approaching a problem. Whether his results are of benefit scientifically or practically is a minor circumstance, so that he gain the proper attitude toward future work." "The master's thesis does not need to be regarded as a finished product and generally is a preliminary study. There should be no library thesis subject for this degree. All doctor's work should be of a high scientific nature, developing thoroughly the historical side, and of some attainment in an experimental way. The mere performing of experiments is not enough. The work should be carried to a finish with a careful analysis of the results as a basis for conclusions." The idea generally prevails, especially for the doctor's degree, that the work should be specific when completed and well presented from the standpoint of the literature and material and also should include a careful and thorough analysis of the subject as a basis for drawing conclusions.

The Best Arrangement that Can be Made at the Present Time to raise the Standards of Graduate Work in Horticulture: Quotations are given from the various answers setting forth the range

of suggestions under this heading. Most of these are stated without revision. "To raise the standard of graduate work in horticulture, to raise the standards of scholarship, enthusiasm and personality in the instructional staff and to include on the graduate faculty only members of the experiment station staff carrying forward research." The establishment of research fellowships and a close working relation between the Adam's Fund projects and the graduate thesis investigation, and better training, both in the instructional staff and in the preparation of graduate students, were suggested by a number as one of the most immediate steps which should be taken in this direction. The suggestion was made for the formation of a standard and its promulgation through the medium of a society such as the American Society for Horticultural Science, similar to that supplied by the committee on undergraduate instruction. Another suggested the concentration of advanced work in two or three institutions with some cooperative arrangement by means of which the graduate students could be divided between them. "Carry the graduate research work along with the experiment station work. If the latter work is organized on fundamental lines this should operate to the advantage of both student and station." It is held by one that no rule can be laid down, that the value of graduate work depends entirely upon the man under whom it is done. "Experiment station work is the life of the graduate school. If the college and station were separated it would be only a few years until the teaching staff would be as incompetent to guide graduate students as the extension service is now." "The standards of graduate work in horticulture can best be brought about by breaking up horticultural departments into their component parts. If a division is to have a title of Department of Horticulture, it should be a department of orchard management, limiting its field to the general social, political and economical questions relative to orchard culture." It was suggested also that a research propaganda committee might attempt to elevate the standard of our horticultural departments by "direct appeal to workers or by a publicity campaign in which research ideals might be set forth. The American Society for Horticultural Science might appoint a committee on graduate research to whom would be submitted thesis outlines for approval."

The suggestions as to the best method of improving graduate work have included the following points which are worthy of emphasis: First, better training in the teaching staff; second, better preliminary training for the students; third, limited graduate instruction for the research men; fourth, the formation and adoption of a standard to follow; fifth, the breaking up of horticultural departments into their component parts, and sixth, the placing of emphasis upon fundamental training.

Shall the Thesis Work be Carried Forward in Horticulture or in One of the Fundamental Sciences: The vote on this question shows a divided sentiment. Twenty-four were in favor of carry-

ing work forward in horticulture and eleven in the fundamental sciences. Some expressed the opinion that the master's work should be taken in horticulture, but that the doctor's thesis should be worked out in one of the fundamental sciences. Others felt that the proper arrangement to make would be to have the thesis work done in horticulture with a cooperative arrangement with the other sciences. One correspondent says "My idea is to select some horticultural problem that requires a deep plunge into one of the fundamental sciences to bring about its solution. The sooner we can get our students to fully understand that real horticultural problems require fundamental research, and that in order to carry forth research they must have training, the sooner we will be able to give the men the training they should have to enable them to advance the horticultural cause in general. If we are to raise the standard of graduate work we must not fail to impress upon the man the fact that horticulture itself is not a science, but is made up of fragments of many sciences." "It seems to me that horticulture is the application to the problems of certain crops, of the fragmentary body of science which is distributed among such subjects as botany, chemistry, with their subdivisions. I see nothing in the way of graduate work being administered in a horticultural department which involves sustained study in one or more lines of fundamental science." Apparently there are some workers in the field of horticulture who are yet to be convinced that fundamental work cannot be given in horticulture.

Is It Desirable From the Standpoint of Graduate Work to Separate College and Station: The replies on this point were decisively against separating college and station. College is used here in the sense of carrying with it the graduate school. The total vote stands 24 to 1 against separation. The points mentioned in favor of an intimate relation between college and station were mainly grouped about the idea of the stimulus which would come to the staff and to the student, or that it would be best for the staff or that it would be best for the student.

There was no doubt as to the desirability of having the investigators give the advanced instruction. One expressed the opinion that work should not be given by one who is not carrying on research. The idea was expressed also that graduate work and station investigation lie right along the same line and where a man is doing research work he could with advantage spend some time with graduate students. "If experiment station men above a certain grade are to teach it would be better for them to confine their attention to graduate students." "If the graduate research can be carried along with the station research and the latter is organized on fundamental lines the work will be attractive to the students desiring to obtain the best opportunities for graduate work. The staff will have the advantage of the conscientious and careful work of a number of students capable of working along fundamental lines. Separating the college and station staff would result in the narrowing of the field of observation and study of

the station staff. From both the standpoint of the staff and the graduate student, therefore, it seems desirable that the college and station staff should be together."

Would It Be Desirable to Have a Close Working Relation Between the Station Projects, Especially Adam's Fund Projects, and Graduate Thesis Investigation: Here again the answers are decisive and show conclusively the place the experiment station is taking in relation to the graduate work. The answers were 25 to 2 in favor of a close relation. The objection to a close working relation between the station projects and the graduate students seemed to be the "undeniable fact that such relation has a strong tendency to make the station project secondary." Some advised putting students on Adam's Fund projects, others did not. "I think there should be the closest kind of a working relation between the station projects, especially the Adam's Fund projects and graduate thesis investigation. This is what makes the station a graduate school. It is simply made up of experimental research problems and the atmosphere is just the right kind to stimulate and bring out the best that is in a student working for a higher degree." The sentiment was also expressed that a close working relation between the station and graduate school should be extended only to the doctor's degree.

The Best Adjustment or Arrangement Within the Staff so That More Time of Qualified Instructors Will be Given to Graduate instruction: The suggestions as to the best method of accomplishing this purpose, while quite varied, were for the most part direct to the point and showed pretty clearly the direction changes would take to accomplish this purpose. There was a recognition almost unanimously expressed that the men giving the graduate work should be research men of high standing. Under this heading again the desirability of an intimate relation with the experiment station was emphasized. The changes included "more men on the staff," "setting some apart as strictly research men," "conferences between the staff members and the graduate students in the way of seminars," and "limiting the amount of undergraduate instruction so that each member of the staff could be carrying forward some research." It was evident in this connection that as a general proposition our departments are undermanned, so that members of the staff do not have sufficient freedom of time for research and study.

The desirability of a close working arrangement between the research men, especially those conducting the Adam's Fund research, and the graduate thesis investigation, especially the doctor's, was emphasized in a number of cases. The graduate work and the Adam's Fund investigations appear to be influential in raising the standards of research as well as the type of problem for research. In concluding this section quotations will be given from the correspondence. These will serve to show the viewpoint at a number of institutions.

"An increase of the staff with more time of qualified men free from research and graduate instruction. The point is to have more time available with the right type of men. Most of us are kept busy with work already at hand so that no adjustment is possible."

"Our plan is to assign each graduate student to the member of the staff that comes closest to bring the specialist in the line in which his thesis is taken. The help that the student receives from other members of the staff is incidental to instruction received from them in regularly scheduled courses."

"Confining the teaching to three credit hours per week, especially with members of the scientific staff. Teaching of the undergraduates can best be left to men who are doing the routine work of the department rather than actually thinking out problems. These men dealing with the undergraduates should be primarily teachers and secondarily investigators."

"It seems impractical to make any definite adjustments. The tendency where station work and graduate instruction are combined is to devote most of the time to the students and unless there is a sufficient staff the research work is the first to suffer. This is perhaps one of the most valid objections to the combination of station and instructional work. Our aim has been to avoid overloading men with teaching so that each member will have time left for research."

"I wish I could answer this question, for if I could. I would certainly bring happiness to universities all over the country. It seems to me that matters will have to be settled according to circumstances that prevail locally in each institution. In general those men who show the greatest aptitude for research are the ones who should be given facilities for research and also to whom the direction of graduate thesis problems should be given. In these cases the thesis problems ought to be intimately associated with the general research problems carried by the station men. Both the instructors and students should have vital interest in the problem."

"No instructor should give graduate work who is not himself doing investigational work of high grade and no investigator should be burdened with so many graduate students as to cause serious interruption in his investigations. It appeals to me as an important thing to establish that graduate work should be very different from undergraduate work. In many places graduate students work in a large measure by close association with the instructor and by frequent short consultations and suggestions, but without expecting to attend graduate courses of lectures. Investigational work in undergraduate institutions has developed largely on the lecture system; while it appeals to me that graduate work on the contrary should not be expected to develop in this form, but should be based on personal study and personal initiative and that the student is benefited in proportion to the little time that is given to his instruction. In other words, that the graduate

work should be a field for the student to bring out his originality. While part of the instruction may be given by lectures in graduate work, it has always appealed to me that there should be a minimum of the course requirements and lectures."

"I think there are few men capable of giving first class graduate instruction. I believe that in most of our institutions we are more likely to find better qualified men doing research work than exclusively on the teaching staff. On the other hand, the station research man is liable to know little about students and is liable consequently not to be able to direct graduate students to the best advantage."

In closing the discussion it seems to the committee that there is one point which will bear careful consideration by the Society. That is the one raised in the second part as to whether or not thesis research should be carried forward in the department of horticulture. You will recall that there was a division on this point, twenty-four in favor of it and eleven against it. We wish to simply raise the question as to whether or not the situation in horticulture is different from that in agriculture, that is, in section M of the American Association for the Advancement of Science. Some of the sciences brought over into agriculture seem quite specific and well defined, and yet in the application of chemistry to agriculture, we have so many phases that it is complex indeed. The question is worth considering as to whether or not there is any fundamental distinction between an applied science and a so-called pure science. The proofs, the facts, and the methods are the same in applying a science as in extending it. In fact, the application of a science very frequently results in the extension of that science as well as in its application. It has been pointed out in other discussions on graduate work before the Society that in order to apply a science it is necessary to know it. So, it would seem that in horticulture for instance, as in the broader field of agriculture, we would have to consider it an art as practiced by the grower; but research within this field is not necessarily of a superficial or incidental nature on this account. The whole range of the applied sciences can be brought to bear upon the problems concerning horticulture the same as they can be in the general field of agriculture, medicine or engineering. This is indicated very well by the replies so that when it comes to graduate work it seems that the recognition given to fundamental training in these reports is sound and that fundamentally the strong sentiment of aligning the graduate work up with the research is certainly in the right direction; but we must ever keep in mind the fact that in agriculture the departmental divisions of the subject are purely arbitrary and that as Bailey points out such divisions do not exist in nature. The main reason for a division of horticulture is that there will be grouped about the subject matter in this field men trained and responsible for applying fundamental research direct to its problems. However, experience has shown that where there is the responsibility of direct applica-

tion, more consistent results can be obtained than where the research in a particular field, as horticulture, is of an incidental nature in one of the other fundamental sciences.

In the Massachusetts Agricultural College, graduate work is designed to equip men along two lines of work, the professional and the research, the former type of development being along that primarily followed by undergraduate work with a lower requirement of the sciences and humanities. As a point of entrance to a discussion of this question Dr. Shaw proposes three phases of it for discussion. These are direct and to the point in this connection, and the committee would like to have a frank discussion of them. They are as follows:

1. Is it desirable to have a course of graduate study and training to fit men for the practice of horticultural professions different from that designed to fit men for horticultural research?

2. If such a differentiative course is given, what principle should govern its nature and development?

3. Should such a course have a degree of its own such as Master of Agriculture and Doctor of Agriculture? Or will the usual Master of Science and Doctor of Philosophy be more desirable?

If the Society wishes to continue this committee we suggest that the reports in the future be much more specific in nature and cover merely one point as for instance, the presentation of thesis research or thesis outlines or a more thorough investigation of the best policy with reference to graduate fellowships, or a study and presentation of outlines for graduate courses in horticulture. These are merely suggestions and the committee believes that it would be best for the Society to indicate the line along which the report should be given. It is understood, however, that your committee should have the closest cooperation with the horticulturists in any of the investigations. We wish to suggest for the committee of the future a fuller set of answers where methods of viewpoint and judgment are concerned.

(This report is based on answers to the questionnaire from the following states: California (Berkeley), California (Riverside), Colorado, Delaware, Florida, Georgia, Idaho, Indiana, Iowa, Kansas, Maine, Massachusetts, Michigan, Minnesota, Montana, Nebraska, Nevada, New Hampshire, New Jersey, New York (Geneva), North Carolina, Ohio, Oregon, Vermont, Virginia, Washington, West Virginia, Wisconsin, and Wyoming.)

LINEs OF WORK IN WHICH THE MEMBERS ARE ENGAGED.

At the New York meeting the following resolution was adopted:

"There is a general feeling that the Society should, from time to time, assemble and publish a list of the various lines of work in which its members are engaged; for this reason your committee presents the following:

Resolved: That the Secretary be requested to secure annually from the various agencies represented in the Society a statement of the horticultural investigations and experiments which they are conducting, and that this information be published in the annual report of the Society."

In carrying out the instructions of this resolution the Secretary circularized the membership on January 5, 1917, and the following report of projects is the result. As the Secretary understood the intent of the resolution it was to secure titles of lines of work only without discussions of the objects or results. Acting upon this interpretation he has assumed the responsibility of abbreviating, restating and rearranging some of the titles in an attempt to make the report as uniform as possible in the limited amount of time available for this purpose. No attempt was made to get lists of lines of work at institutions with which our members are not connected.

It was thought best to report by states arranged alphabetically and omit the names of members. For future reports, if the members desire fuller statements on lines of work than those given herewith, they should communicate such desire to the Secretary.

DOMINION OF CANADA.

CENTRAL EXPERIMENTAL FARM. *Ottawa.*

Variety tests of apples, apricots, cherries, figs, mulberries, pears, peaches, plums, quinces, grapes, blackberries, raspberries, strawberries, currants, and gooseberries.

Tests to determine individuality in apple trees.

Pollination studies of apples, pears, plums, and cherries.

Tests of close planting and pruning of apple trees—surplus trees to be removed when permanent trees require the space.

Methods of pruning apple trees at the time of planting.

Cover crops for orchards.

Determination of best stocks for apples and plums.

Top grafting to determine influence on relative hardiness and time of bearing.

Variety tests of asparagus, beans, beets, brocolli, Brussels sprouts, cauliflower, cabbage, carrot, celery, corn, cucumber, endive, eggplant, kale, kohlrabi, lettuce, muskmelon, watermelon, onions, peas, peppers, parsley, pumpkins, potatoes, radish, parsnip, rhubarb, salsify, spinach, squash, vegetable marrow, tomato, turnip, and some others of minor importance including herbs and salads.

Comparative results from vegetable seeds of same varieties from different seed firms.

Determination of the value of home grown seeds of peas, beans, tomatoes, corn, and melons in comparison with imported seeds.

Methods of pruning and training tomatoes.

- Determination of best date for planting potatoes of mature or immature seed of previous year.
- Determination of relative earliness of varieties of potatoes by digging test.
- Determination of productiveness and quality of varieties of peas and beans.
- Determination of best distance apart to sow peas with seeder.
- Testing the effect of Farmogerm on crop of peas.
- Comparison of hotbed celery and cabbage plants—with and without the use of paper pots.
- Determination of best time to sow celery seed and transplant the plants.
- Comparing pruned and unpruned melon plants.
- Test of ornamental plants including annuals, biennials, herbaceous perennials, trees, shrubs, and vines.
- Comparison of different kinds of trees and shrubs for hedge purposes.
- Determination of best methods of winter protection for roses.
- Fall versus spring planting of sweet peas, also continuous cropping versus rotation of sweet pea crops.
- Determination of best distance apart for planting different annuals.
- Subirrigation of flower beds and borders.
- Comparison of home grown versus imported seeds of ornamental plants.
- An effort to obtain hardy trees and shrubs by growing them from home-grown seed.
- Comparison of different kinds of timber trees in plantation of single and mixed species at different distances apart.
- Experiments in spraying with fungicides and insecticides on fruits and vegetables, and on ornamental plants.
- Breeding work with apples, pears, plums, cherries, grapes, gooseberries, raspberries, and strawberries, to obtain desirable varieties for different sections.
- Plant breeding of beans, peas, potatoes, onions, corn, potatoes, and muskmelons for earliness, yield, and quality, and to study laws of heredity.
- Plant breeding of geraniums, sweet peas, columbine, poppies, and phlox to improve existing varieties to study laws of heredity.
- Greenhouse methods of culture of varieties of fruits, vegetables, flowers, ornamental trees, and shrubs; also the testing of different kinds of greenhouse benches.

ONTARIO HORTICULTURAL EXPERIMENT STATION, *Vineland Station*.

- Variety tests of 164 apples, 124 pears, 150 peaches, 130 plums, 7 quinces, 58 cherries, 138 grapes, 30 currants, 31 gooseberries, 83 strawberries, and raspberries, blackberries, and apricots.
- Fall versus spring plowing of various cover crops in apple and pear orchards.
- Cultivation experiment with apples.

Lime sulphur versus soluble sulphur for apple scab control.

Thinning apples.

Influence of various stocks on early bearing of Northern Spy apple.

Winter versus summer pruning of apples.

Spring versus fall planting of apples, pears and plums in dynamited and dug holes.

Pollination tests of Northern Spy apple.

Dwarf versus standard pear trees.

Control of pear blight.

Determination of varieties most successful in fertilizing the Duchess pear.

Record of blossoming dates of pears.

Autumn versus spring planting of peaches.

Peaches on peach roots versus plum roots in heavy clay soil.

Inoculation experiments with little peach and peach yellows diseases.

Cause and control of canker of peach and brown rot of plum.

Testing storage qualities of commercial varieties of peaches.

Testing commercial value of nectarines in Ontario.

Fall versus spring planting of cherries including comparative tests of heavy and light pruning at planting time.

Testing *Vinifera* grapes on Concord roots and on resistant stocks.

Comparative test of various grape pruning systems.

Summer pruning versus disbudding of grapes.

Correlation between number of buds left and vigor, productivity and longevity of grape vines.

Correlation between size and weight of grape seed and germination and vigor of seedling grapes.

Determination of best method of germinating grape seed.

Self fertility tests of all leading varieties of grapes.

Value of certain self-fertile varieties as pollenizers for self-sterile varieties of grapes.

Determination of sugar and acid content of leading varieties of grapes at various stages of maturity.

Irrigation versus non-irrigation of strawberries and raspberries.

Fertilizer experiment with strawberries.

Shipping precooled strawberries to the Canadian West.

Storage test of 17 varieties of strawberries.

Improvement of strawberries by runner selection.

Testing strawberries for jam making.

Tests of viability of strawberry pollen.

Hybridizing apples, pears, plums, peaches, cherries, strawberries, raspberries, blackberries, currants, gooseberries, tomatoes, cucumbers, and flowering plants.

Growing seedling fruits and vegetables of which one or both parents are known.

The use of tents over trees as an aid in extensive pollination, and a study of temperatures inside and outside the tents.

Stimulation tests with peaches, grapes, strawberries, and tomatoes to induce fertilization with other materials than pollen.

Artificial methods of pollen germination.

Asparagus variety tests.

Irrigation versus non-irrigation of asparagus and onions.

Irrigation versus non-irrigation and application of nitrate of soda to carrots, celery and early beets.

Value of different varieties of peas for canning.

Test of Mendel's work with nine varieties of peas used by him.

Northern versus southern grown potatoes for seed.

Hill selections of potatoes.

Seed selection in beets, carrots, celery, melons, onions, peas, rhubarb, tomatoes.

Comparative yield of tomato plants from cross-bred versus open-pollinated seeds.

Tests of premature pollinations in the tomato.

Tests of length of time pistils of tomato remain receptive.

Soil temperature test under irrigation.

DEPARTMENT OF AGRICULTURE, *Victoria, B. C.*

Testing productiveness of different varieties of fruits.

Spraying to control apple scab.

Cold storage of apples.

Methods of irrigating, harvesting, curing and storing onions.

DOMINION EXPERIMENTAL FARMS, *Kentville, N. S.*

Variety tests of apples, peaches, pears, and plums.

Dwarf apples versus standards.

Close versus wide planting of fruit trees.

Intercropping of standards with small fruits and vegetables versus plums and cherries for fillers between standards.

Fertilizer experiments in the orchard.

Small fruit tests including English gooseberries, American gooseberries, currants, raspberries, blackberries and strawberries.

Orchard spraying experiments with different fungicides and insecticides for scab control.

Home versus imported nursery stock.

Variety tests with varieties of ornamental plants including flowering plants, trees, and shrubs.

Experiments with filberts.

Vegetable growing experiments and variety tests with all the different vegetables.

Potato culture experiments. and potato improvement work.

UNITED STATES DEPARTMENT OF AGRICULTURE.

OFFICE OF HORTICULTURAL AND PROMOLOGICAL INVESTIGATIONS.

Viticultural investigations—Vinifera, American Euvitis and Muscadine grapes.
 Fruit production and adaptation.
 Nut culture investigations.
 Mississippi Valley hardy-fruit breeding.
 Fruit improvement through bud selection.
 Rosaceous-fruit breeding and domestication.
 Fruit history and classification.
 Fruit nomenclature.
 Fruit identification and variety collections.
 Fruit utilization investigations.
 Vegetable handling and storage investigations.
 Truck crop production.
 Truck crop fertilizers.
 Potato investigations.
 Adaptation of truck crops to organic soils (mucks and peats).
 Production of vegetable and flower seeds.
 Standardization of varieties of vegetables through selection.
 Improvement of vegetables through hybridization and domestication.
 Irish potato investigations.
 Vegetable history and nomenclature.
 Vegetable utilization investigations.
 Landscape gardening.
 Floriculture.
 Bulb growing.

NORTHERN GREAT PLAINS FIELD STATION, *Mandan, N. D.*

Variety testing of fruits, vegetables, deciduous and evergreen trees, herbaceous perennials and other ornamentals.
 Cultural experiments with fruits and vegetables.
 Breeding to secure cold and drought resistant varieties of fruits, especially the native plum, choke cherry, pin cherry, sand cherry, June berry, high-bush cranberry, raspberry, grape Buffalo berry, currant, crataegus, and hazel nut.
 Plant breeding work with vegetables, ornamentals, and deciduous trees.
 Determination of the effects which influence hardiness by use of hardy, semi-tender, and tender varieties of apples on hardy and tender roots of apples, and by cultural treatment of plums, deciduous trees, shrubs, and perennials.
 Co-operative shelter belt development.

FIELD WORK AT *Wenatchee, Washington.*

Investigations and control of powdery mildew, bitter pit (Baldwin spot), Jonathan spot, and stigmanose of apples.
Stigmanose of plums.
Drought injury to fruits.
Orchard tests of commercial fungicides.

FIELD WORK AT *Vancouver, Washington.*

Investigations of pear scab and brown rot of prunes and comparative efficiency of dust and liquid sprays to control these diseases.
Orchard tests of commercial fungicides.

FIELD WORK AT *Salem, Oregon.*

Investigations of brown rot of cherries.
Orchard tests of commercial fungicides.

ALABAMA.

ALABAMA POLYTECHNIC INSTITUTE, *Auburn.*

Study of varieties of peaches.
Summer pruning versus winter pruning of peaches.
Peach budding.
Propagation and cultivation of varieties of pecans.
Spraying experiments with fruits and nuts.
Testing varieties of grapes to discover which ones are best adapted to southern conditions.
Study of the Smyrna fig for possible introduction later.
Experiments with sweet orange, Satsuma orange, other citrous fruits, sweet potato, tomato, pepper, and egg plant.

ARKANSAS.

UNIVERSITY OF ARKANSAS, *Fayetteville.*

Xenia in apples.
Sterility and fertility of varieties of apples.
Grape variety test of 143 varieties.
Strawberry variety test of 17 varieties.
Irish potato variety test of 70 varieties.
Demonstration work consists of pruning, spraying, fertilizing, cultivation, packing, and grading of fruits.

CALIFORNIA.

UNIVERSITY OF CALIFORNIA, *Berkeley.*

- A study of the factors influencing seed formation in citrus fruits.
- A study of date seedlings of known parentage reared from cross-pollinated seed.
- A study of the pomegranate industry in California.
- A study of the conditions under which citrus fruits are produced in northern California.
- Investigation of the cause of so-called "June drop" of Naval oranges.
- The avocado in California.
- Variation in oil content of immature and mature avocados of a single variety.
- The process of ripening avocados.
- Systematic pomology of the table figs grown in California.
- A study of Capri figs and commercial caprification in California.
- An investigation of the efficacy of present methods in the dried fig industry of California.
- Correspondence course in fig culture, date culture, citrus and other semi-tropical fruit culture.
- Improvement of bearing of grape varieties by selection.
- Tests of new or little known varieties of grapes.
- Resistant stocks for California grapes.
- Transmissability of degree of permanence of vegetative variations of the grape.
- Relation of degree of maturity of grapes to quantity and quality of raisins.
- Resistant stocks for raisin varieties.
- Wine grapes for the San Joaquin Valley.
- Varieties and methods suitable for grape growing in Imperial Valley.
- Amounts of wine and by-products yielded by grapes in California.
- Improvements of methods of preparing unfermented grape juice.
- Standards of composition of California grapes and wine.
- Preparation of collection of olive trees at Davis, Kearney and Imperial, and of specimens at Berkeley.
- Improvements in methods of picking olives.
- Collection of data to aid in the establishment of standards for wine, raisin and shipping grapes.
- Cost of manufacturing olive oil and pickles in California.
- A study of methods of making glacé fruits.
- Unfermented orange juice.
- Unfermented lemon juice.
- Methods of preparing various fruit juices.
- Citrus by-products.
- Effect of cross pollination on Muscat in vineyard.
- A study of the rooting habit of grape vines under irrigation in the different soil types in Imperial Valley.

Seasonal activities of grape varieties.

Comparison of the effects of long and short pruning on varieties which are commonly pruned both ways.

Relation of the number of vines per acre to the quantity and quality of the crop.

Relative fruitfulness of canes originating on 2-year-old wood (fruit canes) and canes originating on older wood (spurs and suckers).

Effects of summer pruning on the quantity and quality of the crop on the vigor of the vines.

Best arrangement and pruning of vines in Muscat vineyard.

Raisins as a feed for swine.

Relation of *Oidium* to the keeping qualities of shipping grapes.

Demonstration of methods of growing raisin grapes.

Table grapes for the San Joaquin Valley.

Irrigation of vineyards.

Walnut mutant investigations.

Cross breeding peaches.

Tobacco investigations.

Potato improvement.

CITRUS EXPERIMENT STATION, *Riverside*.

The effect of different stocks on commercial species and varieties of citrus.

Study of the comparative infectiousness of the crown gall organism (*Bacterium tumefaciens*), with special reference to finding resistant forms of *Prunus* suitable as a root stock for the various stone fruits.

Lemon decay fungi, with special reference to their control by wash water disinfection.

Black pit of lemons.

Investigations as to the causes, manner of development, and treatment of gum diseases of citrus and other fruit trees.

Some studies on mottling of citrus trees.

The nematode problem on citrus trees.

A study of the relative influence of different factors on the composition of certain fruits and nuts.

The breeding and improvement of citrus fruits.

The origin, nature and inheritance of apparent mutations in certain plants.

A study of the chemical and physical effects of nitrate of soda on citrus soils.

Experiment in the management of old groves.

A study of the fumigation process with special reference to the chemical problems involved.

Spraying for insect pests on citrus and olive trees.

A comparative study of *Coccus Citricola* Campb. and *Coccus hesperidum*, Linn.

The dispersion of scale insects by wind.

Injection of cyanide salts in citrus trees for control of scale insects, and of blackleaf 40 in walnut trees for the control of the walnut aphid.

The use of the fungus *Isaria* in controlling the black scale.

Survey of situation of the citrus products and by-products industries in Southern California.

Walnut breeding investigations.

Walnut root stock investigations.

A physiological study of the effect of pruning upon the growth and productiveness of citrus trees and other horticultural plants grown under irrigation in arid regions of Southern California.

A study of ammonification and nitrification in the soils of Southern California with special reference to the fertilizer plots of the Citrus Experiment Station.

The control of lemon decay fungi by wash water.

Walnut blight, investigations for control.

Fixation of nitrogen by, and nitrification of, legumes.

UNIVERSITY FARM, *Davis*.

Almond culture.

Pecan culture.

Pollination of *Domestica* and *Trifoliata* plums under California conditions.

Planting distances for deciduous orchard trees.

Student laboratory plantings—A study of fruit tree stocks, pruning and planting methods.

The training and pruning of deciduous orchard trees.

Apricot pruning.

Irrigation of orchards and small fruits.

Orchard soils investigations (tests of mulches for orchard trees).

Orchard soils investigations (effect of tillage practices on soil moisture content and growth of trees).

Pollination studies.

Fruit-bud formation.

Nature and causes of growth periodicity in fruit trees.

Relation of growth stimuli to fruitfulness and quality of product in orchard trees.

Orchard management.

CONNECTICUT.

EXPERIMENT STATION, *New Haven*.

Experiments in growing early tomato plants.

Experiments on the value of various methods of growing and storing seed potatoes as aids in maintaining the vigor of the stock where they are grown for a number of consecutive years in this State.

Variety test of lettuce adapted to summer culture.

Cultural experiments with Chinese cabbage.

Cultural experiments with witloof chicory.

Spraying and seed treatment as means of controlling celery blight.

DELAWARE.

DELAWARE COLLEGE, *Newark.*

Role of potash, phosphoric acid and nitrogen in growing peaches.

Role of potash, phosphoric acid and nitrogen in growing apples.

Testing varieties of apples, pears, peaches, plums, grapes, cherries, and bush fruits.

Hereditry studies on peaches.

Use of nitrate of soda as a top dressing for peach and apple orchards

Central leader versus open head pruning for apples.

Rooting of apple tree cuttings.

Cytology of peach fertilization and the influence of over-dose of phosphoric acid upon fertilization of the embryo.

Study of plant food requirements of the tomato.

Comparative test of early varieties of tomatoes.

Comparative test of late varieties of tomatoes for canning purposes.

Hereditry studies of Volga cabbage.

Comparative variety tests of pole lime beans.

Comparative variety tests of bush lime beans.

Demonstration work in pruning young peach orchards, from first to third year; use of nitrate of soda on peach trees; thinning peaches; dusting strawberries with sulphur and arsenate of lead for control of strawberry weevil; spraying tomatoes for septoria leaf spot; spraying cantelopes for lice.

FLORIDA.

UNIVERSITY OF FLORIDA, *Gainesville.*

Effects of various chemicals on the growth of citrus trees and upon citrus fruits.

Study of diseases of insects of citrus fruits and control of same.

Study of diseases and insects of truck crops.

Study of mangoes and avocados, and of new varieties of horticultural plants.

GEORGIA.

UNIVERSITY OF GEORGIA, *Athens.*

Variety testing of apples, peaches, and citranges.

Fertilizer tests on apples.

Management of a large pecan orchard as a commercial proposition.

Study of rosette of the pecan.

Experimental work with cantaloupes, particularly of spraying.

Organization of the cantaloupe and watermelon growers.

Study of ornamentals adapted to Georgia conditions.

Work with tomatoes in the commercial districts in testing fertilizers, etc.

Demonstrations in home orchard, home garden, and landscape garden work.

Experiment in experimental evolution.

GEORGIA EXPERIMENT STATION, *Experiment.*

- A study of color inheritance, and causes of sterility in *Vitis rotundifolia*.
- A study of the two groups of varieties of the *Hicoria* pecan and their relation to self-sterility and parthenogenesis.
- Influence of certain fertilizers on quality, texture, and keeping quality of sweet potatoes.
- Breeding a strain of tomatoes resistant to blossom end rot.
- A study of the transmission of characters resulting from crosses between collard and cabbage.
- To determine number of applications of sprays, etc., to control early blight on Irish potatoes.
- The effect of crown gall on apple trees after several years of growth.

ILLINOIS.

UNIVERSITY OF ILLINOIS, *Urbana.*

- Lettuce breeding studies.
- Soil mixtures for greenhouse lettuce and tomatoes.
- Tomato selection for *Fusarium* resistance.
- Fertilizer experiments with potatoes, melons, and sweet potatoes.
- Sweet potato selection tests.

INDIANA.

PURDUE UNIVERSITY, *Lafayette.*

- Comparison of the effects of different methods of orchard management on the rate of growth, earliness of bearing, yield, and size of fruit; and investigations of the chemical, physical, and biological changes in the soil. This includes several methods of mulching, clean culture, and cover cropping.
- Meteorological and climatological records, and correlation of some soil changes and tree behavior.
- Studies on morphology and physiology of trees.
- Studies of the soil conditions as they exist and the effect of changes in cultural methods of these conditions.
- Studies to determine the reasons for the soil changes and for the observed reactions of the trees to such changes as are found.
- Chemical analysis of the soil in experimental plots.
- Bacteriological investigations of the soil in experimental plots.
- Soil aeration studies.
- Absorption study.
- Cover crop investigations.
- Rejuvenating old orchards.
- Pruning young apple trees.
- Peach tree spraying.
- Strawberry culture systems.
- Bush fruit investigations.
- Phenological observation.
- Cucumber disease control.
- Head lettuce investigations.

IOWA.

IOWA STATE COLLEGE, *Ames*.

Apple breeding.
Cold storage for Iowa apples.
Orchard management.
Orchard heating.
Variety studies.
Orchard stocks investigations.
Orchard humus investigations.
Orchard fertilizer investigations.
Spraying apple orchards.
Control of blister canker of apple.
Crown gall study.
Fruit survey of Ames.
Vineyard investigations.
Cooperative marketing of deciduous fruits.
Cooperative fruit crop reporting with United States Weather Bureau.
Potato and sweet corn investigations.
Irrigation of truck crops.
Downey mildew of lettuce.
Cabbage yellows.
Study of ornamentals and their use in farmstead planting.
Carnation breeding.
Demonstration work:—spring pruning and spraying; summer spraying; planting and topworking hardy apples; listing apple growers and buyers for college clearing house; collecting 1916 crop results; advice on the grounds for farmsteads, parks, consolidated schools or other public projects; potato growing; boys' potato clubs; clearing house for sale of potatoes in car lots; truck-crop service; control of pests of vine crops and onions; diseases of cabbage; home gardens on farms and in towns; boys and girls garden club work; farmers' institutes; short courses, lectures, bulletins, correspondence.

MAINE.

UNIVERSITY OF MAINE, *Orono*.

Variety testing of apples and small fruits.
Relation of scion over stock in apples.
Hybridizing work with and study of self pollination of self sterility in apples.

MARYLAND.

MARYLAND STATE COLLEGE, *College Park*.

A test of trellis and training systems for grapes.
A test of *Vinifera* grapes under Maryland conditions.

- Grafting the Delaware grape on various stocks.
- Grape breeding, with reference to the inheritance of characters in hybrids between varieties of the *labrusca*, *vinifera*, *estivalis*, and *riparia* species.
- Testing new varieties of strawberries.
- Methods of growing the strawberry crop.
- Variety tests of bush fruits.
- Test of quince varieties.
- Production of apple stocks by cuttings.
- Variety test of apples.
- Apple breeding.
- Pear breeding.
- Variety tests of hardy types of pecans and Persian walnuts.
- Collection of phenological data of stone fruits.
- Variety tests of stone fruits.
- The effect of dynamite blown holes upon the growth of peach trees.
- Relative tardiness of the different races of the peach.
- The effect of fertilizers and cultivation upon the hardiness of the peach.
- Geranium breeding.
- A study of reproductive processes in *Diospyrus virginiana*.
- A study of reproductive processes in *Asimina triloba*.
- The effect of fertilizers on plant variations.
- Seed saving for adaptation, disease resistance, etc.
- Location of seed pods on ten weeks stock (*Mathiola Icana Annuua*) as related to the doubling of the flowers.
- Improvement of the McCormick potato by hill selection and otherwise.
- What amount of fertilizers and manures it is necessary to apple to keep soil fertile for truck crops.
- Testing vegetable novelties.
- Stable manure, rotted and fresh, versus commercial fertilizers for truck crops.
- Best method of using crimson clover when sown as a fertilizer for tomatoes.
- Permanent plots of sweet potatoes.
- Inheritance of the climbing habit in lima beans.
- Hand versus natural pollination of greenhouse tomatoes and its relation to the yields of varieties.
- The improvement of tomatoes for canning purposes.
- Fertilizer requirements of asparagus.
- The effect of continual selection of different size potato tubers for seed.
- The yield of tomatoes as affected by varying percentages of nitrogen in fertilizers.
- Biochemical and physiological studies on the rest period of potato tubers.
- Metabolic changes in tubers during sprouting.
- Laws and mechanism of inhibition and correlations in the growth of buds on potato tubers.

A chemical and physiological study of "spindling sprout" disease of the potato tuber.

Changes in the Irish potato tuber during storage.

Metabolism of storage organs in poor ventilation, with especial reference to the effect on carbohydrate transformations.

Breeding tomatoes resistant to *Fusarium* wilt.

Life history of *Septoria lycopersici* and its relation to the tomato blight.

The brown rot of fruits and the *Sclerotinia* causing it, with special reference to the blossom blight.

MASSACHUSETTS.

MASSACHUSETTS AGRICULTURAL COLLEGE, *Amherst*.

Studies in plant breeding:—inheritance of pigmentation in garden beans; isolation of pure races in squashes; correlation of seed weight and vine length in peas; effect of selection within the pure line in peas.

The interrelation of root and scion in apples.

The climatology of fruits:—effect of local climate on varieties; relation of topography to winter killing of fruit buds in peaches.

Pruning experiment with apples with especial reference to head formation.

The effect of cover crops on growth and production in apples.

Tests of varieties of fruits.

Experiments in the intensive planting of fruits.

Tests of spray materials and methods.

Tests of fertilizer in the orchard.

The behavior of apples in cold storage.

Demonstration in fifteen orchards which have been set since 1910.

Demonstration of the manufacture of orchard by-products.

Lectures and demonstrations at extension schools.

A special extension school in pomology.

A pruning, spraying, and apple grading and packing campaign.

An apple packing school held at the College each fall.

A state-wide campaign for the observation of a national apple day.

Monthly letters to county agricultural agents.

Occasional letters to demonstration orchard owners.

SPRINGFIELD, *Hampden County*.

Demonstration work in,—

Encouraging cooperative buying and selling associations.

Orchard cultivation and cropping.

Planting fruit trees.

Use of nitrogenous fertilizers and cover crops.

Thinning fruit.

Spraying fruits and vegetables.

Market gardening.

Vegetable gardens for the farm home and factory-worker home.

Apple club work for boys and girls.

Method of care of woodlot and shade trees.

MICHIGAN.

AGRICULTURAL COLLEGE, *East Lansing.*

Apple propagation.

Topworking Northern Spy on early bearing varieties.

Apple variations.

Thinning apples and plums.

Bud selection and performance records of apples and grapes.

Stocks for sour cherries and plums.

Orchard fertilizers.

Orchard heating experiments.

Investigations of the critical temperatures of fruits.

Studies of reciprocal influence of stock and scion of ligneous and herbaceous plants

Storage experiments—at low temperatures.

Testing European varieties of grapes.

Grape spraying experiments.

Fruit and flower breeding investigations.

Inheritance studies of small fruit crosses.

Control of peach borer and leaf curl.

Raspberry anthracnose control.

Testing spraying materials.

Comparison of dust and liquid sprays.

Potato spraying experiments.

Potato fertilizer experiments.

Asparagus and rhubarb selection.

Asparagus storage.

Forcing whitlock chicory.

MINNESOTA.

UNIVERSITY OF MINNESOTA, *St. Paul.*

Pruning the apple.

Cider and vinegar making qualities of Minnesota apples.

Blueberry studies.

Nut culture.

Determination of the value of certain plants for hedges.

Studies in sterility in grape, strawberry, and plum.

Study of the inheritance of fruit characters.

Breeding for hardiness in fruits.

Study of relation between structure and hardiness in the plum.

Cooperative orchard management experiments.

Variety tests of fruits.

Breeding and selection of bean, cucumber, lettuce, melon, onion, pea, squash, and tomato.

Potato investigations in hill selection, the testing of varieties and seedlings, and in maintaining yield.

Tests of hardiness and uses of ornamental annuals, perennials, trees, and shrubs and hardy plants.

MISSOURI.

UNIVERSITY OF MISSOURI, *Columbia.*

A study of the factors influencing the rest period of horticultural plants.

Orchard and strawberry nutrition.

The self-fertility and self-sterility of fruits.

Peach breeding for hardy sorts.

Bud selection from high yielding parents of apples and strawberries.

Spraying fruits for insect and fungous diseases.

Orchard heating (for protection in years when spring frosts occur).

Examination of fruit buds in winter for forecasting probable bloom.

Treatment of apple canker diseases.

Season of transplanting and its relation to the growth and development of fruit trees.

Orchard tillage.

Fruit bud development as influenced by treatment and previous crops.

Seed potato investigations.

Methods of hardening off plants to fit them for transplanting.

Cooperative Demonstration Work:—Renovation pruning of neglected orchards; Maintenance pruning of well managed orchards; Pruning and shaping of young orchard trees; Spraying orchards for insect and fungous diseases; Methods of pruning types and species of grapes in various fruit soils; Spraying grapes; Orchard soil management; Grading and packing various types and varieties of apples for market.

THE MISSOURI BOTANICAL GARDEN, *St. Louis.*

Breeding of primroses.

Experimental work with hardwood cuttings.

Ramming of trees.

Electrification of plants outdoors through the medium of a specially designed apparatus.

Nutrition of greenhouse plants with CO₂.

MONTANA.

UNIVERSITY OF MONTANA, *Bozeman.*

Tests of tree fruits.

Thinning experiments with apples.

Pruning experiments with fruit trees.

Orchard cultural tests.

Variety tests of small fruits.

Tests of ornamental trees and shrubs.

A study of tree injury caused by abnormal food supply. (In co-operation with the Department of Chemistry.)

Variety tests of vegetables.
 Storage tests with cabbage.
 A study of factors which tend to induce premature seeding of celery.
 Seed selection work with tomatoes.
 A comparison of straw mulch and cultivation in dry land gardening.
 Variety tests with potatoes.
 Thinning experiments with potatoes.
 Tests of distances of planting potatoes.
 Mulching experiments with potatoes.
 Seed selection work with potatoes.
 Variety tests with potatoes.
 Methods of potato culture.
 Straw mulch for potatoes.

NEW HAMPSHIRE.

NEW HAMPSHIRE COLLEGE OF AGRICULTURE, *Durham.*

Fruit bud formation.
 Variety test of apples.
 Variety test of small fruits.
 Study of the status of the blueberry industry in the state.
 Inheritance of color in carnations.
 Adaptation of varieties of tomatoes to New Hampshire conditions.
 Variety test of tomatoes for forcing in the greenhouse.
 Mendelian inheritance in squashes.
 Extension projects in orchard renovation, cultural methods, pruning and thinning fruit, care of young orchards, and cover crops.

NEW JERSEY.

RUTGERS COLLEGE, *New Brunswick.*

Plant breeding:—*heridity*, to study true reciprocals for determining the effect of the direction of the breeding of beans, corn, egg-plants, squashes, peppers, and tomatoes; *environment*, to determine where in the pod the best seeds of peas and beans for planting are found; *toxicology*, the relation that may exist between certain injuries to plants and the constituents of artificial soils.
 Fertilizer, cover crop, spraying, and borer control experiments with peaches.
 Classification of peaches.
 Pruning experiments with peaches, apples, and pears.
 Variety tests with peaches, apples, pears, plums, strawberries, and bush fruits.
 Dynamiting experiments with peaches, apples, and pears.
 Plant studies with strawberries.
 Soil and fertilizer studies with roses, carnations, and gardenias.
 Variety tests with roses and carnations.
 Effect of type of bench construction upon the growth of carnations.

Factors affecting the splitting of the calyxes of carnations.

Breeding work with peaches and carnations.

Strain studies with beets and radishes.

Effect of heredity and environment upon the floral parts of the tomato.

Demonstration work in apple and peach orchard management; spraying of peaches and apples for production of perfect fruit; the pruning of fruit trees; renovation of old or neglected orchards; top-working of apples and peaches; picking of fruit at proper stage of maturity; mixing and applying a mixture of hydrated lime, sulphur and glue as a substitute summer spray for self-boiled lime-sulphur; fruit survey work in certain important fruit centers; packing of peaches in Georgia carriers; experiments in control of borers in peach trees by use of sodium cyanide and ammonium sulphate; test of rust resistant asparagus roots; test of disease resistant cabbage; culture and spraying methods with cantaloupes; soil sanitation and spraying with bordeaux for the control of celery diseases; cultural methods with horseradish; use of lime upon vegetables; sowing of parsnip, spinach and carrot seeds in winter; onion maggot control; corn ear worm control on sweet corn; soil sanitation and seed selection with sweet potatoes; special strains of tomatoes; methods of propagating tomato plants.

NEW YORK.

CORNELL UNIVERSITY, *Ithaca*.

Osmotic relationship and insipient drying in fruit trees.

Heredity studies in peach, plum, persimmon, and Persian walnut.

Relative hardiness studies of the roots of different fruit plants including blackberry, raspberry, gooseberry and currant.

Bush fruit fertilizer experiment.

Fruit tree shaping experiment to study effect on yield.

Study of color in fruits.

Study of the causes of "June drop" of fruit trees.

Study of the effect of thinning fruit on the behavior of individual fruit spurs.

Study of history, evolution and botany of flowers and decorative plants.

Study of varieties of peonies.

Study of sweet peas both under glass and in the open.

Study of the gladiolus.

Testing varieties of roses for hardiness, etc.

Experiments with phlox, iris, aquilegia, primula, orchid, and hardy varieties of chrysanthemum.

Extension work is done by means of demonstrations in orchard operations, in thinning, grading and packing fruit; by lectures on fruit culture and garden flowers; by educational exhibits at state and county fairs; by correspondence course, demonstration schools and winter short course.

Methods of keeping flowers.

The effect of ether on bulbs and hardy plants.

The fertilizer requirements of the tomato, by yield and greenhouse tests.

A study of space requirements and of varieties of tomatoes.

Training and pruning the tomato.

A taxonomic study of the varieties and strains of celery, tomato, and beans.

A study of methods of training greenhouse cucumbers as influencing earliness and yield.

Cooperative experiments to show the best method of supplying nitrogen to muck land crops.

Demonstration trials to indicate the best methods of fertilizing the crop of late cabbage.

EXPERIMENT STATION, *Geneva*.

Variety testing—number of varieties as follows:

apples.....	368	apricots.....	40	black raspberries..	23
pears.....	175	nectarines.....	33	purple raspberries	5
quinces.....	19	gooseberries....	74	yellow raspberries.	1
plums.....	279	currants.....	35	dewberries.....	8
cherries.....	110	blackberries....	40	grapes.....	390
peaches.....	373	red raspberries ..	29	strawberries.....	69

Fruit breeding—number of seedlings now growing 3200 apples, 1500 pears, 150 plums, 500 grapes, 300 raspberries (selected from about 1500), and 700 strawberries.

Rose and orchid breeding, to study color inheritance.

Apple fertilization at the experiment station and throughout the state.

Tillage experiments and cost of growing apples.

Bud selection in apples and violets.

Heavy versus light pruning and high versus low heading with apple, pear, plum, peach and cherry, and tests of various dressings for pruning wounds.

Tomato breeding—inheritance of inflorescence of English types.

Cabbage—the relative value of selfed and open pollinated seed.

Bean—plant selection, and studies with the Red Kidney and pea varieties.

Garden peas—plant selection and problems with one or more varieties.

Culture of unusual vegetables as French artichoke, chicory, and sea kale.

VINEYARD LABORATORY, *Fredonia*.

Experiments with commercial fertilizer, stable manure, lime, and green manure, on grapes.

Pruning and training varieties of grapes.

Resistant stock experiments with different varieties of grapes on

Riparia gloire, Rupestris St. George, Clinton, and on own roots.
The use of 300 varieties of grapes for breeding and variety testing.
Testing grape seedlings in breeding work.
Study of temperature and water requirements of varieties of grapes.
Testing of Vinifera varieties of grapes.

NORTH CAROLINA.

STATE BOARD OF AGRICULTURE, *Raleigh*.

Commercial culture of pecans and variety testing for different sections of the state.
Pecan breeding to originate new varieties for the northern portion of the pecan area.
The culture of Persian walnuts, filberts, almonds, and Japanese walnuts.
Commercial culture of summer apples in the coastal region of the state.
Methods of culture, propaganda, and fertilization of Muscadine grapes and experiments to produce better varieties.
Behavior of varieties of the various fruits under different soil and climatic conditions.
Culture methods for commercial peach production.
Peach breeding to produce new varieties best suited to the coastal region of the South.
History of all varieties of fruits originating in the state.
Demonstration of best methods of orchard management throughout the fruit regions of the state.
A study of the wild fruits of the state.
An investigation of thermal belts or frostless zones.
Variety testing of sweet potatoes.
Sweet potato storage experiments.
Irish potato seed production and its relation to northern and southern grown tubers.
Experiments in commercial strawberry culture.
The breeding of new varieties of strawberry for the South.
Control of wilt disease of lettuce.

EXPERIMENT STATION, *West Raleigh*.

Hybridizing of rotundifolia grapes with other species.
Heridity in rotundifolia grapes.

NORTH DAKOTA.

NORTH DAKOTA AGRICULTURAL COLLEGE, *Agricultural College*.

Variety test of apples.
Variety test of small fruits.
Variety test of potatoes and use of immature potato seed.
Comparative trials of various commercial strains of so-called "pedigree" strawberries.

- Tomato breeding to secure an early, meaty tomato.
- Variety testing of vegetables, particularly sweet corn, onions, cabbage, cauliflower, and celery.
- Culture experiments of tomatoes, cauliflower, and celery; also a fall seeding experiment of early hardy vegetables.
- A model farm vegetable garden adapted to the conditions and needs of North Dakota farm homes.
- Variety tests of asparagus and culture trial of the Martha Washington variety on depth of planting, age of crowns, manuring, mulching, varying lengths of cutting season, and comparison of male and female plants with regard to season, quality, and total yield.
- Tests of annual and perennial flowers, shrubs, and trees for ornamental purposes.
- Extension work in fruit growing, vegetable gardening, and landscape gardening.

OHIO.

AGRICULTURAL EXPERIMENT STATION, Wooster.

- Variety testing as follows: 400 apples; 200 peaches; 100 plums; 75 cherries; 100 grapes; 60 currants; 25 gooseberries; 300 strawberries.
- Apple breeding for disease resistance and to study standard varieties as pollenizers for each other.
- Pruning young apple trees to determine the effects of different kinds and times of pruning on rapidity of growth, vigor of tree, time of coming into bearing and yield of fruit.
- Orchard culture of apples.
- Fertilization of apple and peach orchards.
- Collecting and testing all seedling apples of the state which show promise of superior value.
- Testing the value of apples as fillers in intensive orcharding.
- A study of the rapidity and manner of healing of pruning wounds.
- Storage studies of apples and grapes.
- A test of the use of sawdust and pomace for mulch.
- Testing the effect of delayed application of dormant spray.
- Greenhouse soil treatment.
- Head lettuce breeding for disease resistance.
- Early cabbage variety tests.
- Breeding cabbage for wilt resistance.
- Potato variety test.
- Chinese cabbage improvement by selection and crossing for garden, cold frame and greenhouse conditions.
- Variety test of tomatoes pruned to single stem and staked.
- Test of crosses of tomato F_1 generation under greenhouse conditions.
- Planting large and small asparagus plants to determine the effect upon yield.
- Commercial fertilizers for greenhouse use.
- Spinach, endive, cress, beans, kohl-rabi, Chinese cabbage, etc., in greenhouse for early fall crop.

Cold storage tests of greenhouse and field grown vegetables.

Testing sun-sprouting, greening, change of seed and size of Irish potato seed as affecting the yield; also the production of high grade seed potatoes.

A soil test, including manure and chemical fertilizers upon county farms.

A comparison of fertilizers with cover crops as to value in soil improvement.

OHIO STATE UNIVERSITY, *Columbus*.

Demonstrations,—all-year demonstrations in pruning, spraying, fertilizing, thinning, grading and packing in 40 orchards. Also 150 other pruning and spraying demonstrations.

Illustrated lectures and practical work in landscape gardening for homes and rural schools.

PENNSYLVANIA.

PENNSYLVANIA STATE COLLEGE, *State College*.

Influence of fertilization on growth, yield, and commercial quality in apples and peaches.

Influence of cultural methods on growth, yield and commercial quality in apples.

Influence of cover crops on growth, yield, and commercial quality in apples.

Influence of scion-selection on the same characters.

Relative value of certain stocks for use in top grafting.

Fertilizer injury to fruit trees and its control.

With asparagus:—variety testing; influence of size of crown; applying manure and commercial fertilizer at time of planting; relation of size of seed to vigor of plants; relative value of seed from different portions of the plant; growing for profit on land fertility suitable for the production of general farm crops.

With cabbage:—variety testing of early and late varieties; influence of size of seed; relation of seed selection to earliness of yield and uniformity of type; study of root development of seedlings as influenced by culture and environment previous to final transplanting and the effect on the crop; fertilizer requirements; breeding late varieties; combating club root.

With Tomatoes:—variety testing; influence of seed selection; a Mendelian and statistical study of inheritance; fertilizer requirements.

RHODE ISLAND.

RHODE ISLAND STATE COLLEGE, *Kingston*.

Use of muck, green manures and chemical fertilizer as substitutes for stable manure in growing vegetables.

Rotation of vegetable crops.

Surface irrigation as affecting various soil treatments.

TEXAS.

AGRICULTURAL AND MECHANICAL COLLEGE OF TEXAS, *College Station*.

Studies of crown gall.

Breeding work with dewberries, blackberries and raspberries.

Introduction of horticultural plants.

Peach breeding and the introduction of long-lived peach stock.

Variety tests on citrus fruits and methods of production from frosts.

A variety test on pecans.

Investigation of best pecan seed for producing stocks and the effect of these stocks on four standard varieties.

Variety testing of pecans and Persian walnuts.

Topworking pecans on pecan and hickory stocks.

Demonstration work in planting home gardens and home orchards, rejuvenating apple, peach and pear orchards; gardening and marketing of fruit; control of sweet potato and tomato diseases.

VERMONT.

UNIVERSITY OF VERMONT, *Burlington*.

The aerial fertilization of plants with carbon dioxide.

The control of quantity and quality in Hubbard squash.

Causes and remedies of self-sterility in strawberries.

Mutual influence of stock and scion in cherry grafting.

VIRGINIA.

UNIVERSITY OF VIRGINIA, *Blacksburg*.

Breeding late blooming varieties of apples.

Commercial value of dwarf apples.

Variety studies of tree fruits.

Soil management, fertilization, and spraying experiments with apples.

Effects of soil environment on fruit bud formation.

Effects of pruning on fruit bud formation.

Resistance of tomato varieties to blight.

VIRGINIA TRUCK EXPERIMENT STATION, *Norfolk*.

Truck crop cultural investigations.

Strain and variety tests of cabbage, potatoes, and other vegetables.

Sweet potato investigations, including cultural methods, seed storage problems and improvements of strains by selection.

Fertilizers and soil requirements for various vegetables.

Effect of continued application of various fertilizer ingredients and combinations on crop production, and their residual effects upon the soil.

Peanut rotation.

Cover crop and truck crop rotations.

Sweet potato breeding and improvement.

Sweet potato storage.

Cultural experiments with onions.

Tomato breeding and variety work, cultural experiments.

Egg Plant breeding and cultural experiments.

Cultural experiments with peppers.

Control of diseases of spinach, sweet potatoes (in hotbed, field and storage house), Irish potatoes, egg plant (including breeding for wilt resistance), cucumbers in cold frame, head lettuce, lima bean, watermelon, muskmelon, and peanut (with reference to varietal resistance).

Plant disease survey of Eastern Virginia.

Control of clover crown-rot caused by *Sclerotinia trifoliorum*.

WASHINGTON.

STATE COLLEGE, *Pullman*.

Self-sterility and cross pollination of apples, pears and cherries.
Mendel's law in relation to blackberry and raspberry hybrids.

Winter injury to fruit trees.

Soil-moisture in the orchard in its relation to the keeping quality of apples.

Orchard cover crops.

Renovation of prune orchards in Clarke county.

Frost injury to tender plants and tree blossoms.

Shade and ornamental trees

Ornamental shrubs and vines.

Variety testing of garden vegetables.

WEST VIRGINIA.

UNIVERSITY OF WEST VIRGINIA, *Morgantown*.

Pollination of the apple to study self-sterility in certain varieties.
Physiological effect of pruning apple and peach trees in varying amounts at various seasons. Metabolism of the apple has been carefully studied in this connection.

Physiological effect of pruning cherry, plum, pear, and quince trees.

Apple orchard culture experiments.

Effect of thinning fruit on annual bearing of apples.

Fertilizer for apple and peach trees of different ages.

Variety test of tree fruits.

Variety test and study of fertilizer and pruning requirements of bush fruits.

A study of several factors influencing strawberry production, such as fertilizers, varieties and their adaption, systems of planting, and the effect of plant selection.

General survey of the small fruit industry.

- Variety test, fertilizer test, cultural methods, and effect of pruning on yield and vigor of grapes.
- Demonstrational cooperative orchard and variety testing work.
- Test of spray nozzles.
- Breeding of sweet potatoes to study the effect of hill selection on yield and vigor.
- Irish potato breeding to study the effect of bud selection; experiment conducted on the tuber unit plan.
- Potato cultural experiment to study the various factors affecting yield and vigor.
- Potato variety test.
- Improving poor soil by means of moderate applications of commercial fertilizers and manures and the use of cover crops while producing profitable truck crops.
- Demonstration and experimental market gardens.
- Extension work in demonstrations on tree fruits, small fruits and vegetables, and the keeping of accurate records of costs, yields, etc.
- Extension work by means of farmers' institutes, extension schools, correspondence courses, judging at district and county fairs, and special assistance to individuals.

WISCONSIN.

UNIVERSITY OF WISCONSIN, *Madison*.

- Root hardness of apples.
- Methods of pruning young apple trees.
- The effects of dynamite in tree planting.
- Comparative value of trees of different ages for orchard planting.
- Orchard cover crops in their relation to soil temperatures and prevention of winter injury.
- Factors in fruit bud development in apples as related to biennial fruiting.
- Moisture losses during winter as an indication of probable hardness.
- Variation in flower development as a factor in orchard spraying.
- Factors in the production of scion roots.
- Fertilization of young and bearing cherry orchards.
- Studies in fumigation with hydrocyanic acid gas.
- Effects of crossing on yield in F_1 tomato hybrids.
- Factors influencing the keeping quality of squash in storage.
- The effects of different sprays in the setting of fruit in forced tomatoes.
- Factors influencing the forcing of rhubarb.
- Potato plant food requirements.
- The increase of prolificacy in carnations through selection.
- Studies of tobacco root rot and other tobacco diseases.
- Inheritance in the tobacco plant as related to productiveness and disease resistance.

Demonstration work in orchard management, spraying, pruning, and fruit packing; improvement of public and home grounds; potato development; tobacco seed bed sterilization; root rot disease prevention.

WYOMING.

UNIVERSITY OF WYOMING, *Laramie*.

Variety testing, propagating, and hybridizing varieties of fruits.

ITEMS OF BUSINESS.

The amendment to the constitution was adopted changing the name of the Society from Society for Horticultural Science to American Society for Horticultural Science.

It was decided to have two meetings in 1917,—a field meeting of *one* day with the American Pomological Society in September, and the annual meeting of *three* days with the American Association for the Advancement of Science in Pittsburg in December.

Subjects suggested for the next program are,—Methods of experimentation and research; laying out an experiment; symposium on soil moisture under different methods of soil management.

A committee of three on variety testing of fruits was provided for.

The other items of business are covered by the report of the committee on resolutions.

The report of the nominating committee was presented and after some discussion the Secretary was instructed to cast the vote of the Society in favor of the officers and members of committees as given on page 5.

REPORT OF THE COMMITTEE ON RESOLUTIONS.

By W. T. MACOUN, *Chairman*.

PERMANENT COMMITTEE ON RESEARCH AND EXPERIMENTATION.

From year to year committees have been appointed to consider various phases of research and experimentation. In order to secure greater permanence for this work your resolutions' committee suggests the following:

Resolved: That a permanent committee on research and experimentation be appointed by the president to report at its pleasure to the society or to any of its members on any phase of research or experimentation which the committee thinks will aid the Society in its present aims.

Furthermore be it Resolved: That this committee shall consist of three men, one whose chief interest shall be in pomology, one in floriculture, and one in olericulture, and that the first appointments be made for one, two and three years and thereafter, as these appointments expire, all further appointments to be for a period of three years.

PUBLICATION OF LISTS OF INVESTIGATIONS AND EXPERIMENTS.

There is a general feeling that the Society should, from time to time, assemble and publish a list of the various lines of work in which its members are engaged; for this reason your committee presents the following:

Resolved: That the Secretary be requested to secure annually from the various agencies represented in the Society a statement of the horticultural investigations and experiments which they are conducting, and that this information be published in the annual report of the Society.

PROPOSED AFFILIATION WITH THE NATIONAL HORTICULTURAL CONGRESS.

In connection with the proposed affiliation of the American Society for Horticultural Science with the National Horticultural Congress, and the suggestion that two members of this Society be appointed to act as delegates to the National Horticultural Congress, it is the feeling of this Society that without further information in regard to the objects of the National Horticultural Congress, it is not desirable for a resolution to the above effect to be presented at this meeting, but it is hereby resolved that the Secretary shall communicate with the National Horticultural Congress for the purpose of obtaining further information and that the matter be referred to our next annual meeting for action.

ACTION ON BILLS BEFORE CONGRESS.

While your committee does not think it desirable to present a resolution in regard to the bills referred to in Mr. Gifford Pinchot's letter of November 29, 1916, addressed to our Secretary, yet it is believed that the members of this Society all have the best interests of the people at heart and will individually use their influence in protecting such interests, but should any concerted action be taken by other scientific societies the Secretary is instructed to cooperate with them. (The bills referred to are the Shields bill, the Myers bill and the oil land provisions of the Phelan bill).

THE PASSING OF PROF. W. R. LAZENBY.

Resolved; that the American Society for Horticultural Science place on record its appreciation of the loss it has sustained in the death of Prof. W. R. Lazenby, who was an active member of the Society and who by his genial disposition and attractive personality had many friends. It is further resolved that the warm sympathy of the members of our Society be conveyed by the Secretary to Mrs. Lazenby and her daughter, the members of his family who remain to mourn his loss.

MEETINGS IN 1917.

Resolved; that the next annual meeting of this Society be held at Pittsburgh in connection with the meeting of the American Association for the Advancement of Science, and that a field meeting be held with, and at the time of, the meeting of the American Pomological Society in September, 1917.

THANKS OF THE SOCIETY TO COLUMBIA
UNIVERSITY.

Resolved; that the thanks of the American Society for Horticultural Science be tendered Columbia University for the comfortable quarters afforded and courtesies extended its members while holding its annual meeting here.

W. T. MACOUN

A. C. BEAL

R. D. ANTHONY

Committee.

TWO LISTS OF CANDIDATES.

When the nominating committee presented its report it offered only one list of candidates and the question was at once raised that the committee should present two lists of officers according to a motion to that effect carried two or three years previously. The Secretary was appealed to and while he recalled the gist of this motion, he could not give the exact wording. A motion was therefore made and carried that the point of having two lists of candidates be waived for the present meeting. The Secretary has looked up the motion respecting two lists of candidates and quotes the following paragraph from the 1913 report, page 109:

“Upon vote of the Society the nominating committee was instructed in the future to prepare two lists of officers from which the Society will select one.”

The Secretary remembers distinctly that when this motion was being discussed prior to the passage on November 21, 1913, the point was emphasized that all of the names of candidates except that of president might be the same on both lists if the committee so desired. The reason for two lists seemed to be to offer a choice of two candidates for the office of president. Although this motion has been in force since 1913, the nominating committee has not always heeded its instructions.

THE SOCIAL EVENING.

On Thursday evening the members met in one of the parlors of the Belmont hotel and with Dr. L. H. Bailey as leader, had a most interesting and instructive round table discussion on such topics as methods of teaching, methods of laboratory work, methods of attacking experimental and research work, varieties of fruits, etc. The future of the American Pomological Society was discussed at length. It was Dr. Bailey's opinion, and in this the members concurred, that the American Pomological Society should be in the future, as it was in its early life, the society for the amateur fruit grower, and deal largely with varieties and nomenclature rather than with commercial problems. The members expressed their desire to help carry on the society along these lines.

This social evening was declared to be the best we have ever held and it was agreed to make this a regular feature at each annual meeting.

OBITUARY.

WILLIAM RANE LAZENBY.

William Rane Lazenby, professor and head of the department of forestry, died of pneumonia on September 15. He was born at Bellona, Yates County, New York, on December 5, 1850. After receiving his elementary and high school training in the village schools he entered Cornell University from which he graduated in 1874 with the degree of Bachelor of Agriculture.

Since graduation Prof. Lazenby was instructor in horticulture and botany at Cornell from 1874 to 1878 and assistant professor until 1881. In 1881 he came to Ohio State University as professor of botany and horticulture. As the University grew he became professor of horticulture and forestry and later professor of forestry.

He was one of the founders of the Ohio Agricultural Experiment Station and its first director. He had been collaborator for the U. S. Bureau of Forestry for four years, secretary of the Ohio Medical University for 12 years from 1902 to 1914, when it was consolidated with the Ohio State University, and secretary of the College of Agriculture from 1896 to 1906. All of these positions he held while he was actively engaged in serving as a regular member of the faculty of the College of Agriculture.

In point of service he is the second oldest member of the faculty of the Ohio State University, being ranked by Professor Samuel Carroll Derby but a little more than two months and the oldest member of the agricultural college faculty. He saw the University grow from a small beginning of a few hundred students until it had an enrollment of nearly 6000 students.

His contributions to the text books of his favorite sciences were many and his honors voluminous. He also contributed frequently to farm papers and was well known as a speaker at farmers' meetings in many parts of the country. He spent many of his summer vacations in studying horticulture and forestry in Europe. He was a member of many scientific societies. (*From the October number of The Agricultural Student, published at the Ohio State University, Columbus, Ohio.*)



WILLIAM KANE LAZENBY.



ERNEST WALKER.

ERNEST WALKER.

Professor Ernest Walker was born at Brownstown, Indiana, November 12, 1862. In 1847 his father, a Methodist minister, took a supernumerary relation to his conference and moved to New Albany, Indiana, and engaged in the nursery and florist business. Those who knew Prof. Walker in his early childhood state that as a small boy he was a great lover of nature. While attending public school he spent his vacations in his father's nursery, which had much to do with shaping his career. After attending De Pauw University he spent a number of years in this same practical work which he regarded as the best part of his education. During the period of service in his father's nursery he was a faithful student in botany, entomology and horticulture. He became so interested in his studies that it was almost a nightly occurrence for him to retire after midnight. He collected and classified specimens of all the flora of that section of Indiana. At one time he took up the study of medicine, but the love of nature brought him back to the work to which he was so devoted. He entered Cornell University and received the degree of Bachelor of Science in Horticulture in the year 1897. In 1896-97 he was student assistant in horticulture. After graduating he was student in botany at Harvard University. In 1899 he became entomologist at Clemson College, South Carolina.

In 1900 he was made Professor of Horticulture at the University of Arkansas at Fayetteville. From 1903 to 1905 he also filled the positions of State Nursery inspector, and Secretary of the State Horticultural Society most of the time. In October 1913 he entered on his duties as Horticulturist and State Horticulturist at the Alabama Polytechnic Institute, which positions he held until September 1916 when he moved to Bolling, Alabama, to engage in a large horticultural enterprise. He died suddenly at his home in Bolling, December 6, 1916.

He was a good writer and contributed many articles to the horticultural papers and magazines, and to Bailey's Encyclopedia. He was a member of the Society for the Advancement of Science, American Pomological Society, and the American Society for Horticultural Science. His death is keenly felt in the horticultural world.

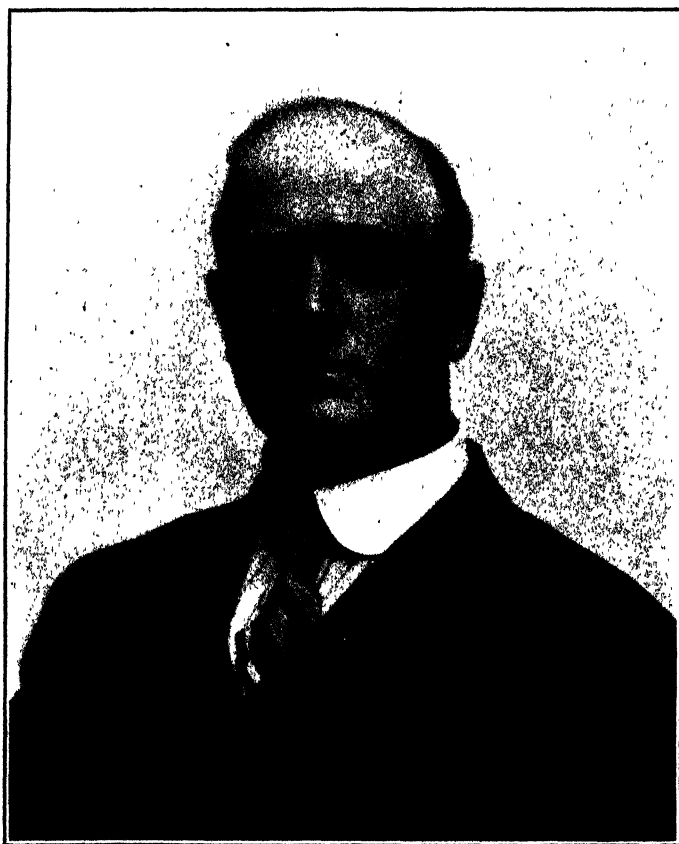
J. C. C. PRICE.

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T. C. JOHNSON.

PROCEEDINGS

...OF THE...

American Society

...FOR...

Horticultural Science

1917

Boston Special Meeting

BOSTON, MASSACHUSETTS,

November 2, 1917,

and

Fourteenth Annual Meeting

PITTSBURGH, PENNSYLVANIA,

December 27, 28 and 29, 1917

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College Park, Maryland.

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OFFICERS AND COMMITTEES FOR 1918.

PRESIDENT.....	C. A. McCUE
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SECRETARY-TREASURER	C. P. CLOSE
ASSISTANT SECRETARY.....	C. E. DURST

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J. C. BLAIR	C. P. CLOSE, Secretary, <i>ex-officio</i>
	C. G. WOODBURY.

NOMINATING

M. J. DORSEY, <i>Chairman</i>	LAURENZ GREEN
C. H. CONNORS	PAUL THAYER
	J. W. CROW

PROGRAM

M. A. BLAKE, <i>Chairman</i>	C. P. CLOSE, <i>ex-officio</i>
C. E. MYERS	H. F. THOMPSON
R. W. REES	E. J. KRAUS
	W. N. HUNT

HORTICULTURAL COURSES

Undergraduate Course	Graduate Course
S. W. FLETCHER, <i>Chairman</i>	W. H. CHANDLER, <i>Chairman</i>
J. W. LLOYD	M. J. DORSEY
B. W. ANSPON	J. K. SHAW

RESEARCH AND EXPERIMENTATION

W. L. HOWARD, <i>Chairman</i>	T. C. JOHNSON	A. C. BEAL
-------------------------------	---------------	------------

SCORE CARD

W. W. TRACY, <i>Chairman</i>	T. C. JOHNSON	W. H. ALDERMAN
------------------------------	---------------	----------------

MEMBERSHIP

C. E. DURST, <i>Chairman</i>	J. E. COIT	T. C. JOHNSON
C. P. CLOSE	A. J. FARLEY	J. G. MOORE
G. C. STARCHER	R. W. REES	J. W. CROW

VARIETY TESTING

J. H. GOURLEY	U. P. HEDRICK	S. A. BEACH
---------------	---------------	-------------

CONSTITUTION*

ARTICLE 1.

The name of this association shall be the American Society for Horticultural Science.

ARTICLE 2.

The object of the Society shall be to promote the Science of Horticulture.

ARTICLE 3.

Any person who is a graduate of an agricultural college and holds an official position in an agricultural college, experiment station, or Federal Department of Agriculture in the United States or Canada, may become a member upon payment of the annual dues of \$1.50.

ARTICLE 4.

Meetings shall be held annually at such time and place as may be designated by the Executive Committee, unless otherwise ordered by the Society.

ARTICLE 5.

The officers shall consist of a President, three Vice-Presidents, and a Secretary-Treasurer, who, together with the chairman of the standing committees, shall constitute a Council to act upon all applications for membership. There shall also be an Assistant Secretary. These officers shall be elected annually by ballot.

ARTICLE 6.

This Constitution may be amended by two-thirds vote of the Society at any regular meeting, notice of such amendment having been read at the last regular meeting.

BY-LAWS*

Section 1. The President and other officers shall perform the usual duties of their respective offices. The President shall also deliver an address at each regular meeting.

Section 2. There shall be a Committee on Nominations consisting of five (5) members, who shall be nominated and elected by ballot at each regular meeting of the Society. It shall be the duty of this committee, at the following meeting, to suggest to the Society names for officers, referees, and members of committees for the ensuing year.†

Section 3. There shall be an Executive Committee, consisting of three (3) members and the President and the Secretary, ex-officio. This committee shall perform the usual duties devolving upon such committee.

Section 4. The Committee on Nomination shall nominate referees and alternates upon special subjects of investigation or instruction, which may be referred to its consideration by the Society. The duties of these referees shall be to make concise reports upon recent investigations or methods of teaching in the subjects assigned them, and to report the present status of the same.

Section 5. There shall be a Committee on Program, consisting of seven (7) members, of which the Secretary shall be one. This committee shall have charge of the scientific activities of the Society, except as otherwise ordered by the Society.

Section 6. There shall be a committee of five (5) members on co-ordination of the horticultural work of the U. S. Department of Agriculture and the Agricultural Colleges and Experiment Stations. (This committee was discontinued about 1912.)

Section 7. The annual dues of the Society shall be one dollar and fifty cents.

Section 8. Ten members of the Society shall constitute a quorum.

*The Constitution and By-Laws as amended from time to time.

†Since 1913 two lists of candidates have been required.

MEMBERSHIP ROLL FOR 1917.

ALDERMAN, W. H.	Experiment Station, Morgantown, W. Va.
ALLEN, F. W.	Agricultural College, Pullman, Wash.
ANDERSON, O. G.	Alaska Agricultural Experiment Station, Sitka, Alaska.
ANSPON, B. W.	Maryland State College, College Park, Md.
ANTHONY, R. D.	Experiment Station, Geneva, New York.
AUCHTER, E. C.	Experiment Station, Morgantown, W. Va.
AUSTIN, C. F.	LaLaguna Plantation Co., Herradura, Cuba.
BABCOCK, E. B.	University of California, Berkeley, Calif.
BAILEY, E. W.	University of Illinois, Urbana, Ill.
BAILEY, L. H.	Ithaca, New York.
BAIRD, W. P.	U. S. Dept. Agr., Washington, D. C.
BALLARD, W. R.	Experiment Station, College Park, Md.
BARNETT, R. J.	State College of Washington, Pullman, Wash.
BARON, LEONARD	Garden City, N. Y.
BARRS, A. F.	Agricultural College, Corvallis, Ore.
BATCHELOR, L. D.	Citrus Experiment Station, Riverside, Calif.
BEACH, F. A.	Ohio State University, Columbus, Ohio.
BEACH, S. A.	Iowa State College, Ames, Iowa.
BEAL, A. C.	Cornell University, Ithaca, New York.
BEATTIE, W. R.	174 Railway Exchange Bldg., St. Louis, Mo.
BECKENSTRATER, H.	Maryland State College, College Park, Md.
BENNETT, E. R.	Extension Service, Boise, Idaho.
BIOLETTA, F. T.	University of California, Berkeley, Calif.
BLAIR, J. C.	University of Illinois, Urbana, Illinois.
BLAIR, W. S.	Experiment Station, Kentville, Nova Scotia.
BLAKE, M. A.	Experiment Station, New Brunswick, N. J.
BRIERY, W. G.	University Farm, St. Paul, Minnesota.
BROWN, B. S.	University of Maine, Orono, Maine.
CADY, LEROY	University Farm, St. Paul, Minnesota.
CALDWELL, J. S.	Experiment Station, Pullman, Wash.
CHANDLER, W. H.	Cornell University, Ithaca, N. Y.
CHENOWITH, W. W.	Agricultural College, Amherst, Mass.
CLARK, C. F.	U. S. Dept. Agr., Washington, D. C.
CLEMENT, F. M.	Univ. of British Columbia, Vancouver, B. C.
CLOSE, C. P.	U. S. Dept. Agr., Washington, D. C.
COIT, J. E.	University of California, Berkeley, Calif.
COLBY, A. S.	University of Illinois, Urbana, Ill.
CONDIT, I. J.	University of California, Berkeley, Calif.
CONNORS, C. H.	Experiment Station, New Brunswick, N. J.
CONOLLY, H. M.	U. S. Dept. Agr., Washington, D. C.
CORBETT, L. C.	U. S. Dept. Agr., Washington, D. C.
CORRIEVEAU, P. E.	Agricultural College, Kingston, R. I.
CRAIG, A. G.	Arcadia Orchards Co., Deer Park, Wash.
CRANDALL, C. S.	University of Illinois, Urbana, Ill.
CRANE, H. L.	University of West Virginia, Morgantown, W. Va.
CRIDER, F. J.	Experiment Station, Clemson College, S. C.
CROW, J. W.	Agricultural College, Guelph, Canada.
CRUICKSHANK, R. R.	Ohio State University, Columbus, Ohio.
CULVERHOUSE, P. E.	Fort. Experiment Station, Vineland Station, Ontario, Can.
CUMMINGS, M. B.	Experiment Station, Burlington, Vt.

- DACY, A. L.....Experiment Station, Morgantown, W. Va.
 DARROW, G. M.....U. S. Dept. Agr., Washington, D. C.
 DAVIS, V. H.....Ohio State University, Columbus, Ohio.
 DEARING, CHARLES.....U. S. Dept. Agr., Washington, D. C.
 DETJEN, L. R.....Experiment Station, West Raleigh, N. C.
 DEWEY, G. W.....Jerome, Idaho.
 DICKENS, ALBERT.....Agricultural College, Manhattan, Kansas.
 DORSEY, M. J.....University Farm, St. Paul, Minnesota.
 DRINKARD, JR., A. W.....Experiment Station, Blacksburg, Virginia.
 DURST, C. E.....University of Illinois, Urbana, Ill.
- EDMINSTER, A. F..... U. S. Dept. Agr., Washington, D. C.
 ERWIN, A. T.....Iowa State College, Ames, Iowa.
 EUSTACE, H. J.....Agricultural College, East Lansing, Mich.
- FAGAN, F. N.....Experiment Station, State College, Pa.
 FARLEY, A. J.....Experiment Station, New Brunswick, N. J.
 FIOR, J. W.....State College of A. and M. Arts, Athens, Ga.
 FISHER, D. F.....Wenatchee, Wash.
 FITCH, C. L.....Iowa State College, Ames Iowa.
 FLETCHER, S. W.....Penn. State College, State College, Pa.
 FLETCHER, W. F.....Woodward, Oklahoma.
 FROST, H. B.....Citrus Experiment Station, Riverside, Calif.
- GLADWIN, F. E.....Vineland Laboratory, Fredonia, N. Y.
 GOODING, J. H.....State College of Washington, Pullman, Wash.
 GOULD, H. P.....U. S. Dept. Agr., Washington, D. C.
 GOURLEY, J. H.....Agricultural College, Durham, N. H.
 GREEN, L. Purdue University, Lafayette, Ind.
- HALSTEAD, B. D..... Experiment Station, New Brunswick, N. J.
 HANSEN, N. E.....Agricultural College, Brookings, S. D.
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 HEDRICK, U. P.....Experiment Station, Geneva, N. Y.
 HEINRICK, A. J.....Cornell University, Ithaca, N. Y.
 HENDRICKSON, A. H.....University of California, Berkeley, Calif.
 HEPLER, J. R.....University of Wisconsin, Madison, Wis.
 HERRICK, R. S.....Iowa State College, Ames, Iowa.
 HIGGINS, J. E.....Experiment Station, Honolulu, Hawaii.
 HODGDON, R. W.....University of California, Berkeley, Calif. .
 HOLLISTER, S. P.....Agricultural College, Storrs, Conn.
 HOLMES, F. S.....Experiment Station, College Park, Md.
 HOOD, G. W.....University of Nebraska, Lincoln, Neb.
 HOSHINO, YUZO.....The Tohoku Imperial University, Sapporo, Japan.
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 HOWE, G. H.....Experiment Station, Geneva, N. Y.
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 JOHNSON, T. C.....Virginia Truck Experiment Station, Norfolk, Va.
 JONES, D. F.....Experiment Station, New Haven, Conn.
- KEYSER, C. N.....State College of Agriculture, Athens, Ga.
 KILHAM, A. D.....Massachusetts Agricultural College, Amherst, Mass.
 KIRKPATRICK, E. L.....Cornell University, Ithaca, N. Y.
 KRAUS, E. J.....Experiment Station, Corvallis, Oregon.
 KYLE, E. J.....A. & M. College of Texas, College Station, Texas.

MEMBERSHIP ROLL.

9

LAKE, E. R.	U. S. Dept. Agr., Washington, D. C.
LANHAM, W. B.	A. & M. College of Texas, College Station, Texas.
LAWRENCE, W. H.	University of Missouri, Columbia, Mo.
LEHRENBauer, P. A.	University of Illinois, Urbana, Ill.
LEWIS, C. I.	Agricultural College, Corvallis, Oregon.
LLOYD, J. W.	University of Illinois, Urbana, Ill.
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LOMBARD, P. M.	U. S. Dept. Agr., Washington, D. C.
LOMMEL, W. E.	Purdue University, Lafayette, Ind.
LUMSDEN, DAVID	Cornell University, Ithaca, N. Y.
LURIE, A.	Missouri Botanical Garden, St. Louis, Mo.
MACKINTOSH, R. S.	University Farm, St. Paul, Minn.
MACOUN, W. T.	Central Experimental Farm, Ottawa, Canada.
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MCCALL, T. M.	University of Minnesota, Crookston, Minn.
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McHATTON, T. H.	State College of A. & M. Arts, Athens, Ga.
MILLER, F. E.	U. S. Dept. Agr., Washington, D. C.
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MONTGOMERY, L. M.	Ohio State University, Columbus, Ohio.
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 STUCKEY, H. P. Experiment Station, Experiment, Ga.
 SUTTON, F. J. North Carolina State College, West Raleigh, N. C.
 SUTTON, F. L. Experiment Station, Morgantown, W. Va.
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 WELLINGTON, R. University Farm, St. Paul, Minn.
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 WHITE, E. A. Cornell University, Ithaca, N. Y.
 WHIPPLE, O. B. Experiment Station, Bozeman, Mont.
 WHITTEN, J. C. Experiment Station, Columbia, Mo.
 WIGHT, W. F. U. S. Dept. Agr., Washington, D. C.
 WHYTE, R. B. 370 Wellrod Street, Ottawa, Canada.
 WICKS, W. H. Experiment Station, Fayetteville, Ark.
 WINSLOW, R. M. Dept. of Agr., Victoria, B. C.
 WOOD, E. G. Massachusetts Agricultural College, Amherst, Mass.
 WOODBURY, C. G. Purdue University, Lafayette, Ind.
 WORK, PAUL Cornell University, Ithaca, N. Y.
 WRIGHT, W. J. Alfred University, Alfred, N. Y.

TREASURER'S REPORT FOR 1917.

Voucher No.	Cr.		
	1916.		
1	Dec. 30	To expenses of Secretary Close in attending 1916 Annual Meeting in New York City, Dec. 28 and 29.....\$	25.95
	1917.		
	Jan. 5	To Stamps	2.00
2	Jan. 9	“ W. M. Holladay, Annapolis, Md., 350 programs for 1916 Annual Meeting	6.50
	Jan. 9	“ Stamps	2.00
3	Jan. 12	“ C. A. McCue, stamps for use of program committee in 1916	4.00
	Jan. 15	“ Stamps	2.00
	Jan. 19	“ Stamps	4.00
	Feb. 1	“ Stamps	2.00
4	Feb. 2	“ Express on report manuscript to the printer in Annapolis	.26
5	Feb. 7	“ The Maurice Joyce Engraving Co., 1 copper half-tone, M. A. Blake, \$2.50; 1 zinc etching — Anthony's paper, \$2.09.....	4.59
	Feb. 12	“ Stamps	3.00
6	Feb. 12	“ Express on letterheads and envelopes from Annapolis .	.37
	Feb. 17	“ Telephone charge to W. M. Holladay, Annapolis, Md...	.25
	Feb. 21	“ Telephone charge to W. M. Holladay, Annapolis, Md. .	.25
	Mar. 2	“ Telephone charge to W. M. Holladay, Annapolis, Md...	.25
	Mar. 10	“ File Case	.45
	Mar. 20	“ Stamps	1.00
	Apr. 19	“ Stamps for mailing 1916 report	16.23
	Apr. 19	“ Stamps	2.00
7	Apr. 30	“ W. M. Holladay, printing 1916 report, 164 pages @ \$1.20 per page, \$196.80, and 3 inserts, \$7.00.....	203.80
8	Apr. 30	“ W. M. Holladay, for 2,500 letterheads and envelopes.	20.00
	June 8	“ Stamps	2.00
	Sept. 24	“ Stamps	2.00
	Oct. 19	“ Stamps	2.00
9	Oct. 29	“ Torsch & Franz, Baltimore, Md., 100 buttons for Boston Meeting	4.55
10	Nov. 10	“ George T. Melvin — The Advertiser-Republican, Annapolis, Md., for printing 300 billheads.....	3.00
	Nov. 12	“ Stamps	1.00
11	Nov. 16	“ Kells, Newark, Del., 200 envelopes for chairman, Program Committee	1.90
	Nov. 22	“ Stamps	2.00
	Dec. 10	“ Stamps	1.00
	Dec. 12	“ Stamps	1.00
		“ George T. Melvin — The Advertiser-Republican, Annapolis, Md., printing 350 programs of 1917 meeting...	7.50
		“ Torsch & Franz Badge Co., 125 buttons for Pittsburg Meeting	4.25
			\$ 334.10

Dr.

1916.		
Dec. 28	By Balance on hand.....	\$ 374.21
1917.		
Jan. 22	" T. C. Johnson, Virginia Truck Experiment Station, Va., reports 1903-4, 1905, 1906.....	3.00
Jan. 23	" P. E. Carreveau, R. I. State College, Kingston, R. I. report 1911.....	1.00
Jan. 29	" Oregon Agr. College, Corvallis, Ore., reports 1912, 1913, 1914,	3.00
Feb. 6	" The Washington News Co., Washington, D. C. report 1915...	1.00
Feb. 10	" Virginia Truck Experiment Station, Norfolk, Va., first eleven reports.....	11.00
Mar. 27	" New Mexico College of Agr. & Mech. Arts, State College, N. M., set of eleven reports and reports for 1912, 1913 and 1914.....	14.00
Mar. 30	" Iowa State College, Ames, Iowa, report 1913.....	1.00
Apl. 20	" F. M. Clement, University of British Columbia, Vancouver, B. C., report 1916.....	1.50
Apl. 30	" Brooklyn Institute of Arts and Sciences, Brooklyn, N. Y., report 1916.....	1.50
May 2	" Georgia Agr. Experiment Station, Experiment, Ga., report 1916.....	1.50
May 7	" Southern Oregon Experiment Station, Talent, Oregon, report 1916.....	1.50
May 7	" University of Minnesota, University Farm, St. Paul, Minn., report 1916.....	1.50
May 7	" Perdue University, Lafayette, Ind., report 1916.....	1.50
May 7	" Georgia State College of Agriculture, Univ. of Ga., Athens, Georgia, report 1916.....	1.50
May 11	" Virginia Polytechnic Institute, Blacksburg, Va., report 1916.	1.50
June 6	" State College of Washington, Pullman, Wash., report 1916...	1.50
June 6	" The Ohio State University, Columbus, Ohio, report 1916.....	1.50
June 6	" University of California, Berkeley, Calif., 2 reports 1916....	3.00
June 6	" Massachusetts Agricultural College, Amherst, Mass., report 1916.....	1.50
June 6	" Louisiana State University, Baton Rouge, La., report 1916..	1.50
June 6	" Kentucky Agricultural Experiment Station, Lexington, Ky., report 1916.....	1.50
June 6	" Ohio Agricultural Experiment Station, Wooster, Ohio, report 1916.....	1.50
June 6	" Pennsylvania State College, State College, Pa., report 1916..	1.50
June 6	" The American News Co., 9 Park Place, New York City, report 1916.....	1.50
June 16	" University of Wisconsin, Madison, Wis., report 1916.....	1.50
June 16	" New Mexico College of Agr. & Mech. Arts, State College, N. M., report 1916.....	1.50
June 16	" Oklahoma Agr. & Mech. College, Stillwater, Okla., report 1916	1.50
June 16	" Iowa State College, Ames, Iowa, report 1916.....	1.50
June 26	" Cornell University, Ithaca, N. Y., report 1916.....	1.50
July 10	" Oregon Agricultural College, Corvallis, Oregon, report 1916..	1.50
July 10	" University of Maine, Orono, Maine, report 1916.....	1.50
July 10	" Department of Agriculture, Harrisburg, Pa., report 1916....	1.50
July 25	" Kansas State Agricultural College, Manhattan, Kansas, reports 1916 and 1917.....	3.00
July 31	" University of Nebraska, Lincoln, Neb., report 1916.....	1.50
July 31	" University of California, Berkeley, Calif., report 1916.....	1.50
Aug. 3	" University of Vermont, Burlington, Vt., report 1916.....	1.50
Aug. 3	" Colorado Agricultural College, Fort Collins, Colo., report 1916	1.50
Aug. 25	" F. C. Steckert & Co., New York, N. Y., first eleven reports (sent to University of British Columbia Library).....	11.00
Sept. 18	" U. S. Experiment Station, Honolulu, Hawaii, report 1916....	1.50

TREASURER'S REPORT. .

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Sept. 24	"	Raphael Meyer, Librarian, R. Veterinary & Agricultural College, Copenhagen, Denmark, set of 12 reports.....	12.50
Nov. 20	"	A. E. Murneck, Iowa State College, Ames, Iowa, report 1916.	1.50
Dec. 28	"	Membership dues paid since the 1916 meeting.....	351.50
			\$ 834.21
Balance on hand.....			\$ 500.11

Respectfully submitted,

C. P. CLOSE, Treasurer.

The Auditing Committee reported that it had examined the accounts of the Treasurer and found them to be correct.

C. A. McCUE,

W. H. ALDERMAN,

R. W. REES,

Auditing Committee.

BOSTON SPECIAL MEETING, 1917

FRIDAY, NOVEMBER 2, 9:30 A. M.

In the absence of President Johnson, Vice-President Macoun presided. This special meeting was held in connection with the bi-ennial meeting of the American Pomological Society. About 30 members were present. Only one session was held and the following addresses were given:

OBSERVATIONS UPON SUMMER PRUNING OF THE APPLE AND PEACH.

BY M. A. BLAKE, *Experiment Station, New Brunswick, N. J.*

The training and pruning of fruit trees has been a common topic of discussion among fruit growers for years. Every horticultural writer has given some attention to this phase of horticulture. However, the issue has not always been clear cut, and problems of training have been confused with plant growth principles and commercial problems. Too often the dominant idea conveyed is that the successful production of fruit is principally a matter of the form of the tree, and that when one is able to prune a tree into a symmetrical habit and to make perfect cuts with the saw and the knife, he has become an expert in pruning. The practice of pruning in America has too often been based upon theory, or has developed into a fad along certain lines.

Horticultural investigations have only recently reached a stage of development where projects as broad and complex as that of pruning can be carried out upon an extensive and accurate scale. Our experiment stations have not been able to provide the trained men and the funds to carry out these problems properly in the past. The fact should not be lost sight of, however, by present day horticulturists that most of the principles of plant growth concerned in pruning have been brought forward at one time or another, and have simply been overlooked or cast aside because their true worth and bearing were not recognized. Many of our present controversies among experts and fruit growers, and the lack of uniformity in methods, are due in a large measure to a lack of knowledge.

A considerable number of pruning experiments with fruit trees are now being conducted in several states, and they are being conducted so extensively and accurately that it is quite certain that within a comparatively short time the subject of pruning will be presented in a complete manner.

Extensive pruning experiments with peaches were begun at the New Jersey station in 1912, when it became apparent that a careful study of the pruning of the peach was necessary in connection with the other investigational work being conducted with peaches. Experiments in the pruning of apples were also started at the same time.

The peach experiments have produced four crops, but the time and labor involved in the tabulation and data have been so great that only a brief summary of the first two seasons' results has been published. Nothing as yet has been published in regard to the apple experiments.

Previous to the planting of these experimental pruning plots, a dwarf apple orchard was established at the New Jersey Experiment Station in 1907, also experimental peach orchards for the study of fertilizer problems. Some pruning tests in these early plantings were the basis of the extensive pruning experiments planned for later. The horticultural work at the New Jersey Station has been greatly disturbed this year by enlistments in the army and navy, and it has not been possible to prepare a complete report upon the pruning investigations in time for this meeting. However, the observations of those who have been conducting the work may be of some special interest as applied to summer pruning. No attempt will be made at this time to discuss the practicability of summer pruning as an orchard practice, but to call attention to its present status and to bring out points which have been observed in the conduct of the New Jersey experiments.

The summer pruning of apples has received special attention in recent years by Alderman and Auchter, of West Virginia, by Gardner and Magnes, at the Oregon Experiment Station, by Batchelor and Goodspeed, of Utah, and others. Summer pruning of the peach is discussed in a bulletin by Keffer, of Tennessee, issued in June, 1914.

Alderman* calls attention to the opinions in regard to summer pruning of 166 fruit growers and gardeners in the British Isle, compiled by The Gardeners' Chronicle, 140 of these reporting from fair to very good results with home fruits, while 26 were doubtful of its practicability.

Vincent¹ in Idaho, found that trees given annual summer pruning only, gave considerably increased yields in the case of some varieties, while in others it was very slight. Dickens,² of Kansas, also reports favorable results with ten-year old apple trees.

Batchelor and Goodspeed³ report that "Trees pruned during the dormant period and also during the summer produced a greater annual twig growth than trees pruned during the dormant season only." They also found, however, that "Summer pruned trees averaged less marketable fruit per tree than either the winter pruned or the unpruned trees," and conclude that "Summer pruning in this orchard has proven neither profitable or successful in increasing crop yields." Alderman & Auchter⁴ state "Early mid-summer and repeated summer pruning as a rule impair tree vigor as evidenced by small annual growth, small leaf area and light colored foliage. Early summer pruning was less deterrent in its effect than was repeated or mid-summer pruning."

* West Virginia Experiment Station. Bulletin 158, page 20.

¹ Idaho Agr. Ex. Station, Bul. 84.

² Kansas State Agr. Exp. Station. Bul. 136.

³ Utah Agr. Exp. Station. Bul. 140.

⁴ West Va. Agr. Exp. Station. Bul. 158.

"There is no evidence to show that either early, repeated or mid-summer pruning will hasten the bearing period of young trees or increase crop production of trees of bearing age."

Gardner,¹ of Oregon, states "Summer pruning of the type described affords a means of developing a fruit spur system in young apple trees earlier than is possible with the ordinary method of winter pruning only; it is estimated that its judicious use with varieties bearing mainly upon spurs will enable the apple grower to bring his trees into bearing approximately a year earlier than is otherwise possible, and still maintain and develop a good frame work." It can be seen from these extracts that there are some differences of opinion in regard to the effect and value of the summer pruning of apple trees. However, there is evidence at hand to clear up some of these differences, but first let us consider the object of summer pruning. It is quite obvious that summer pruning is of little practical interest to commercial fruit growers unless it will promote earlier bearing, increase average production, or result in higher quality fruit and increased profits. The common claim made for summer pruning is that it will bring trees into bearing earlier, and that it may conserve the energies of the tree by directing growth into the desired channels. In other words, it may be employed as a means of training a young tree or of promoting fruit production.

A most common expression in horticultural writings is that winter pruning induces wood growth, while summer pruning induces fruit production, or "Prune in summer to induce fruitfulness and in winter to promote wood growth." Another common statement in regard to summer pruning is that it checks wood growth. The inexperienced might easily infer from such remarks that summer pruning would be an important feature of orchard practice among our fruit growers, while as a matter of fact, it is not. Since summer pruning was practiced abroad before fruit growing became established in America, it is of interest to note the statements of some of the earlier writers, particularly those of Quinteney, published in "The Complete Gardner," at London in 1719, Chapter XXVIII, has the following title: "Of the Different Manners of Ordering a Peach-Tree in the Summer Time." "Gardeners observe three different ways herein:"

The text reads as follows:

1—"Some pull or tear off all young shoots which grow before and behind, and leave but few others; these seem to blame."

2—"Others cut off those shoots within three or four Eyes or Buds of the Branch they grow on; which renders the Tree ugly and disagreeable."

3—"The last manner is, to preserve all the good Branches and nail them up neatly, leaving them to the time of general Pruning, at which time you may preserve those you like best; which is the Course the Author always took."

Under Chapter XXIX he continues: "Whereas Pruning serves only to shorten or take away old Branches, that either by their length, situation or number, annoy a tree; so this Trimming or Picking, is entirely to remove young Branches of the same Year, either thick or small, growing improperly, or to cause Confusion or Prejudice to the whole Tree, or the branch on which they are grown."

¹ Oregon Agr. Exp. Station. Bul. 139, page 35.

"The Time for it is all the Summer, as occasion requires; the sooner the better (if it needs it) to prevent the growth of those useless Shoots that waste a great deal of Sap, and this should be performed on young as well as old Trees."

Several types of summer pruning or pinching are mentioned by this author and the removal of shoots when too numerous is recommended. This undoubtedly means some shoots other than those commonly called water sprouts or suckers by present day fruit growers.

The fact may as well be emphasized at this point that summer pruning, so-called, may consist of two things; the actual removal of entire shoots, twigs and branches thus thinning the top of a tree and the pinching or cutting back of the tips of shoots and branches which alone would tend to increase the thickness of the top. Much of the latter commonly requires some of the former, but when the term summer pruning is used it is important to know what it implies.

The term "pinching" is commonly used by fruit growers and gardeners today, and Quinteney defines this term in the publication of 1719 as follows: "Pinching in relation to gardening is to break designedly a tender Sprig of any Plant whatsoever without the help of any Instrument, only using the nails of two Fingers; your Shoots so served are not so apt to die and grow black, as when cut with a Knife. It may be practiced on Buds or tender Shoots, in April or May, and sometimes in June and July."

He goes on to explain the application of the process as follows:

"This Operation is to be performed upon thick new Shoots, within two or three Eyes of the Branch they grow out of; and the effect is, that instead of one strong wood-branch (that may be obnoxious) a vigorous Tree will put forth two or Three, at those Eyes left; and the sap being now divided, the Branches may be lesser and fit for Wood and Fruit, if they are well placed; but its chiefly to be practiced upon the thick Branches on the top, which would remain useless from their Situation. and yet spend much Sap.

This is not to be practiced on weak Branches; for if they put forth more, those probably be weaker than the Stem so pinched."

It is such points as these that have often been overlooked by American horticulturists. We rush about so fast and attempt so many things that we do not take the time to become fully informed. The question might well be asked that if summer pruning was generally practiced in England why it did not become established here.

The methods of pruning that were considered best in England were undoubtedly introduced into America early in the history of the country, but it became so easy to produce fruit and there were so many other lines of development that the gardener type of fruit growing never became established, and conditions in this country today do not permit such methods being employed in a commercial way. However, our horticulturists may well give thought to facts and principles of pruning and tree management that were recognized by these pioneer gardeners.

Summer pruning, as applied to young trees in the form of corrective pruning or training, is a different matter from the treatment of bearing trees. Even the summer pruning of young trees may take two forms;

one the removal of undesirable shoots and suckers, the other the pinching back of the tips of leading shoots in addition to the removal of undesirable shoots. The effect may be quite different.

We may as well note at this point that Batchelor and Goodspeed¹ in Utah, found that "Rubbing the water shoots out of the center of the tree from time to time during the summer had little or no influence upon crop production." It is reasonable to suppose that the removal of a comparatively small amount of shoot development of this type would have but little apparent effect upon the tree.

One important fact to be determined is whether the removal or pinching back of growing shoots upon young trees will depress their growth.

early summer pruning did not check the increase in size of the trees (as measured by shoot growth) to a degree greater than a correspondingly heavier winter pruning."

The observations at the New Jersey Experiment Station have indicated that summer pruning of the trees the first season they are planted tends to reduce the total shoot growth of the tree. However, if the undesirable buds are rubbed off before they make much growth the amount of shoot growth reduction may be of little or no consequence. Some tests with practical growers have shown that the rubbing off of undesirable shoots low down upon the trunks of peach trees, the first season after planting, may reduce total twig growth slightly, but may save considerable trouble in the pruning off of undesirable suckers at the close of the growing season, and that there will be less trouble from the production of such suckers the following year. While the Experiment Station does not recommend any such summer pruning of trees in general the first season after planting, it does believe that the rubbing off of undesirable buds low down upon the trunks can often be done economically and to advantage where the trees have made a good start and are growing well. While the pinching back of the tips of shoots upon young trees is recommended in Oregon, this has not appeared to be a good practice in New Jersey, except where trees are making a very irregular growth, and where one or two shoots are growing at the expense of others. In this case, the pinching of such shoots at the proper time, especially the peach, can be done to advantage. Results at several experiment stations indicate that such pinchings may not depress the growth of the trees in the least.

We may now turn our attention to the summer pruning of bearing trees. Since the peach differs from the apple in its fruiting habit, it will be discussed separately. Let us first take up the claim made for summer pruning that it induces fruitfulness. Fruit production can only be increased by increasing the number of flower buds in any one year, or increasing the average number formed each year. In the case of the apple, we may have what are termed spur buds, which are formed upon spurs upon two-year or older wood; axillary spurs upon the one-year wood, and axillary and terminal buds upon the one-year wood. It is a

Gardner² states, "Attention is called to the fact, however, that the

¹ Utah Experiment Station. Bulletin 140, page 18.

² Oregon Agricultural Experiment Station. Bulletin 139, page 17.

rather remarkable fact that so many of our horticulturists and fruit growers failed until recently to observe the fact that the apple produces fruit from axillary and terminal buds."

Paddock and Whipple call attention to this fact in "Fruit Growing in Arid Regions" in 1910, page 71. They state: "Many varieties also produce flower buds in the axils of leaves on the growth of the current season, same as the peach. These facts seem not to have been noticed by the horticultural writers, and no doubt this manner of fruit production is uncommon in the East, but under semi-arid conditions where the conditions under which the trees grow are most artificial, such fruit formation is a common occurrence."

Their observations are correct for eastern conditions as well as for western conditions as noted by Gourley and others. Such varieties as Stayman Winesap, Rome Beauty, Wealthy, McIntosh and Bismark, commonly produce axillary flower buds annually in New Jersey. In fact, the Bismark trees in the dwarf apple orchard at New Brunswick have produced practically their entire crops in this manner each year since 1907. One of the principle objects claimed for summer pruning is that it induces fruitfulness. If this is true, it must then increase either the number of spur buds upon the older wood, the production of axillary spur buds upon the new wood, or the number of axillary and terminal flower buds.

Magness,¹ of Oregon, throws some light upon this matter. He experimented with 38 varieties of apples upon Paradise stock. Trees of each variety received four different pruning treatments. One, a pinching back of the terminals, removing not to exceed 20 percent of the current season's growth; two, a heavy heading back removing 50 per cent of the current year's growth, and three, a very heavy heading back, removing 75 to 100 per cent of the season's growth. The heading back was accompanied by enough thinning to open the trees and admit light. It was found that the summer heading back had very little influence upon the development of fruit buds on the spurs down in the tree. This fact is likely to be borne out in other investigations along this line, since pruning of the shoots at the tip of the tree commonly has little influence upon the growth of the lower part of the tree, especially near the trunk. Therefore, the increase in fruit bud formation, where the summer pruning consists of pinching or "tipping back," must largely occur in the form of axillary spurs or axillary buds if at all.

Magness² also found under this method of summer pruning that there were more axillary flower buds upon the unpruned trees than upon those summer pruned, and that the number decreased with the severity of the pruning. He states: "Here is evidence that far more fruit buds are produced on the one-year wood if no summer heading is practiced."

The observations at the New Jersey Experiment Station have indicated that summer pruning of the tips of the shoots of the apple may or may not increase the formation of axillary buds depending upon the variety, the age of the tree, the size of the shoot, the time of the pruning and the character of the season. Bismark trees commonly respond very

¹ Oregon Agr. Exp. Station. Bul. 139, pages 56-58.

² Oregon Agr. Exp. Station. Bul. 139, page 60.

well to summer pinching. On the other hand, young Delicious trees do not. If there is a tendency for a variety to produce axillary buds, summer pruning may succeed quite well, while varieties whose tip growth is slender and does not tend to form axillary buds are not favorable varieties for summer pinching.

Gardner³ reports: "That in all the varieties studied the late shoot growth on the summer pruned trees (i. e. the shoot growth formed after the summer pruning) is comparatively slender." This is in accord with the observations of Quinteney, published in 1719.

It has been observed at the New Jersey Experiment Station, and (undoubtedly) in other numerous instances that a great many more axillary flower buds are produced upon apple trees in some seasons than in others. A proper check to the growth of the trees by dry weather at the right time during the growing season will promote bud development. It is also noticeable in such seasons that any slight check to the development of branches and twigs often results in the formation of even more axillary buds.

The whole problem depends upon the character and condition of the growth of the twigs, and it is at this point that the unqualified statement that summer pruning checks wood growth should be challenged. The pinching of a few leading shoots upon an apple tree in summer has very little effect upon checking the development of the entire tree. In fact, a considerable amount of tip pinching and the removal of some shoots entirely may not reduce the volume of growth made by the tree, and although it may apparently check the shoots so pinched for a time, it excites them into further growth a little later, and the growth so promoted is near the point of pinching and not low down in the tree. Unless the pinching is done too late for any growth to occur, side shoots push out below the point of pinching and continue a late growth, so that instead of checking growth, the summer pinching has only possibly delayed it and excited late growth. The experience at New Brunswick has been that the summer pinching has occasionally happened to precede a period of drought and the development of new shoots has been delayed longer than usual. However, it took place as soon as growing conditions were favorable, and the resulting shoots did not become of good size and thickness before winter. Even when summer pruning was done quite late in the fall, the trees attempted to push into growth below the point of pinching. Another factor which has entered into the problem to complicate the matter is the green aphid. This insect will attack growing shoots of the apple when it will not flourish upon fully developed twigs, and the new shoots developing upon summer pruned trees in mid-summer offer an ideal field for the work of this insect, and unless it is kept under control, the new shoots do not develop properly and injury has actually been done.

To promote generally the growth of spur buds well down upon the branches of young trees it is necessary to slow down or check the growth of the entire tree. Investigations have shown that the pruning of the tips of the new growth has comparatively little influence upon the development of the lower parts of the tree.

³ Oregon Exp. Station. Bul. 139, page 35.

It is well understood that a real check in the development of an apple after it reaches a certain size would tend to cause the setting of fruit buds, but in a number of these summer pruning experiments, such has not taken place. Alderman and Auchter report experiments in the ringing of young apple trees at the same time that summer pruning experiments were conducted, and they report as follows:

"It will be seen that in 1914, the year following the ringing, the ringed trees bore larger amounts of fruit than those in any of the other plots."

This was in contrast to their finding that summer pruning did not hasten the bearing period of young trees. The point of the matter is that the effect of cutting back the tips of growing twigs in summer pruning has an entirely different effect upon the trees than ringing, or girdling. The latter really tends to check the vegetative growth of the entire tree, while summer pruning does not arrest or check the vegetative processes, but encourages them to put forward further development. Gardner indicates that he recognizes this behavior to a certain extent at least, by the following conclusion:

"Summer pruned trees show a tendency to mature their wood a little later in the fall, and might, consequently, be expected to be more susceptible to winter injury. They have not, however, proved more susceptible to bark splitting caused by severe winter weather."

He states further, upon page 34 of the same bulletin: "Caution should be exercised in practicing heavy, early summer pruning in a section having a very short growing season and very severe winters, even though it is evident that such pruning does not render the trees particularly susceptible to certain forms of winter injury." This is clearly supported by observations made upon apples and pears at the New Jersey Experiment Station. The summer pruned trees tend to be excited into late growth.

It is now appropriate to present the evidence secured in the summer pruning of peach trees at the New Jersey Experiment Station. This summer pruning practiced on peach trees has consisted of tipping back the growing shoots in June and July, accompanied by some thinning out of the shoots and twigs. While the trees were still very young, and before they came into bearing, the orchard at New Brunswick experienced a severe drought one season about mid-summer. The summer pruned plots continued growth during the period of the drought, while the unpruned trees and those winter pruned, stopped growth completely.

It is a well established fact that early maturity of the fruit of the peach is promoted by an early cessation of growth of the trees, and that promotion of growth greatly delays the ripening of the fruit. The results at the New Jersey Experiment Station have shown that Elberta peaches which have received no nitrogenous fertilizers since the time of planting ripen their fruit as much as seven to ten days previous to the time of the maturity of the fruit upon those receiving liberal amounts of nitrogen. We would, therefore, conclude that if summer pruning checks wood growth the summer pruned plots would mature their fruit somewhat in advance of trees that had been winter pruned and headed back for example. Such has not been the case, however. The summer

pruned trees have been the last to mature their crops. This clearly indicates that instead of checking the vegetative processes of the tree it excites them to continue further effort. Several experiments of a demonstration nature were conducted along these lines the past summer. Trees having a good set of fruit and making a growth of one foot to eighteen inches at the tips of the branches received a severe summer pruning in July. Almost the entire new growth was cut off at the tips of the branches. Upon some varieties this pruning was done within a few weeks of the time of ripening, on other varieties it was done more than a month in advance of the time of ripening. Upon the early varieties the trees did not have time to make much twig growth following the summer pruning before the crop was harvested. However, it had a marked retarding effect upon the ripening of the fruit. It is, therefore, evident that the summer pruning did not arrest the vegetative processes of the tree, that while in one sense the growth of the tips of the shoots was arrested, still vegetative action must have been taking place because of the general behavior of the fruit. These same trees have since pushed out side buds and have made a secondary growth.

I believe the general acceptance of the statement that summer pruning checks wood growth has been the stumbling block in a great many of our investigations and observations, and while it has been apparently shown that summer pruning in some instances has depressed the actual twig growth of the tree, and the diameter of the trunk, it is not clear that this has been the result of a check to the vegetative processes in the sense that ringing or girdling would be a check.

A tree checked by ringing or girdling of the trunk develops enlarged lenticels, ripens its foliage early, the buds become enlarged and the foliage increases its tannin content, and in the case of a bearing peach tree the fruit becomes astringent because of the accumulated tannin. A tree summer pruned by the pinching of the growing shoots and the thinning out of some of them does not behave in this manner at all, but tends to continue growth.

There is still another feature to the effect of pinching back the tips of shoots of young apple trees that has not been discussed. This is the formation of axillary spurs upon the one-year wood below the point of pinching. Apple trees occasionally produce such spurs even where no summer pruning is practiced, and it has evidently been the theory and hope of a number of investigators that the season's growth below the pinching would function in a similar manner to the two-year old wood. Whether such a development takes place the first season depends upon the variety, the age of the tree, the size and location of the shoot pinched, the time of the summer pruning and the character of the weather during the season when the pinching is done. Varieties which tend to produce axillary flower buds are the most likely to form axillary spur buds following "pinching."

It is, therefore, a most uncertain practice unless one has the skill and the art of the gardener to know just when and how such pinching shall be done, and even then carefully planned work may fail to bring success because of some abnormal condition in the weather which directly affects growth.

Practically all of this discussion upon summer pruning has related to "pinching" or cutting back the tips of the season's growth. Alderman and Auchter, in West Virginia, in their experiment with young trees, started with this method of summer pruning, but later discontinued it and resorted to branch and twig thinning only.

Now, the effect of simply thinning out the branches of young trees in dormant pruning is different in its effect upon growth than the cutting back of the tips of branches, and it is no less so in summer pruning. Here, then, is another chance for confusion unless we keep the type of summer pruning distinctly before us and the difference in principles involved.

Alderman and Auchter* practiced only the thinning out type of summer pruning upon bearing trees in the so-called Boyer orchard. They conclude as follows: "Taken as a whole, the summer pruning did not seem to check seriously the terminal growth in middle-aged bearing trees." From the standpoint of yields they state: "The heavy and moderate dormant prunings seemed to be very satisfactory and uniform in their results, while the results of the different summer prunings were contradictory and unconvincing."

It is apparent that a certain amount of thinning out of branches upon a bearing tree in the summer may have but little effect upon the growth at the remaining tips as is the case with the same type of dormant pruning.

One well known principle of plant growth is that growth tends to be strongest at tips of branches, and where terminals are cut or pinched back growth tends to be strongest just back of the point of pinching or cutting, and its effect may not be apparent very far down upon the branch.

While it was impossible to present the complete data of the summer pruning studies with apples and peaches at the New Jersey Experiment Station at this meeting, it was thought that the fact that the experiments have demonstrated that summer pinching of growing shoots does not check vegetative development in the tree, but encourages late growth and late maturity of fruit would be of special interest to horticulturists.

A PLAN FOR CO-OPERATIVE COLLEGE TRAINING IN PRACTICAL HORTICULTURE.

BY B. S. BROWN, *University of Maine, Orono, Maine.*

During the past decade almost every agricultural college in the United States has been laboring with the problem of increasing the training in practical agriculture. Obviously the purposes of every educational institution are but two, one to supply knowledge and the other to develop skill. For the most part, the supplying of information or knowledge has been fairly well taken care of, and one hears but little sound constructive

* West Virginia Agr. Station. Bul. 158, page 48

criticism. But the phase of the work dealing with skill pertaining to the more simple farm practices has long been a serious problem, and at the present time is far from being satisfactory.

The problem is continually growing worse, due to the increasing number of students entering from the cities and who have no idea of the simple farm practice operations. In some cases such students comprise over fifty per cent of the total enrollment. The solution of the question not only involves practical training for the regular students, but must take into consideration the short courses, and the city people who desire to move into the country and want training along specific lines.

Such opportunities for developing skill in practical work the colleges of agriculture have thus far not afforded, or at best, in an unsatisfactory way. In far too many cases have the regular students graduated without this practical knowledge. Farmers expect much from college graduates, perhaps too much, but the fact remains that many students are made ridiculous by their lack of knowledge of simple things. Obviously the colleges of agriculture are held responsible for such training, and means should be found to fulfill this purpose.

Administrators and teachers in colleges of agriculture have long felt the need of greater efficiency in skill, especially of horticulture, of agronomy and of farm practice. How this can best be obtained is a problem. Why they have never been obtained has been due to the fear of upsetting well established precedents by radical changes in methods of teaching. Some subjects like entomology, chemistry, or pathology, can best be studied in the laboratory supplemented by occasional field trips. With pomology, vegetable gardening, or farm crops, the laboratory method is at best a weak substitute. Skill in farm operations that have to do with seasonal condition, can only be properly acquired by performing the operations at the proper time.

The Present Methods: Some efforts have already been put forth to increase skill in practical work, but opinions have been divided, there has been no uniformity in the efforts and the results have been unsatisfactory. The present methods are widely varied, but some of the more important now in use may be listed as follows: 1. The students are required to secure their training before entering college. 2. Secure it during the college course without help from the institution. 3. Do prescribed summer work on approved farms. 4. Give the students the training as a part of the college course. 5. Graduate them without skill and compel them to secure the practices as best they can.

The defects of the above methods are obvious. The first two throw all the responsibility on the students, without aid or encouragement from the college. The third, that of practice work on approved farms, has been tried repeatedly and only rarely found successful. The student feels that he is working in order to learn, while the farmer wants to place the man where he will be the most efficient. The student is, therefore, kept at one kind of work, without much being accomplished. As a result very few farms are available for this method. Where the training desired is in the more specialized branches, such as nursery work, landscape, etc., the difficulty is increased.

The practice of giving the training during the college course is at-

tended with many difficulties. Very few institutions are located where conditions of soil, climate, etc., are favorable for the varied farming branches. The equipment is often meagre and much of the fruit and vegetable crops are often needed for experimental or demonstration work. No college orchard or farm is expected to be run on a commercial scale, and the student loses all relation to the economic phase of the work. Much of the practice dwindles to mere demonstrations, or to two or three hours' practice where part of the class work and the rest look on. I recall that as a student in one of the best agricultural colleges of the country, my practice with a power sprayer consisted in holding the rod three minutes and shivering in the cold two and one-half hours while the rest of the class took their turn.

In two or three colleges, efforts have been made to correct the difficulty by continuing the class work through the calendar year. This makes it possible for the student to follow each branch of the work in its season and develop skill by doing the work. This is a step in the right direction, but is a long way from solving the problem. Where the agricultural colleges are so located, where the soil or climatic conditions are unfavorable to the growing of a wide range of crops, the students' ideas become distorted and they swing to one branch or another in accordance to the degree of success attained at the college. Students while acquiring skill should also have an eye to the business side or to the profits of the work. Where conditions are favorable, even though the work be scientifically directed, results are not satisfactory.

The result of the present system has been to react unfavorably against the agricultural colleges. All through the East there has been a strong prejudice, among the uninformed, against *college farming*. The fact that graduates have been unable to do such simple things as harness a team, spade in the garden, or properly use a hoe, has tended to maintain this prejudice and create an unwholesome feeling against college students.

The time was when to admit that you were a college graduate, was sufficient to prevent you from being employed in many lines. In my own experience I was refused a registry for employment by one of the best seed houses in New York City because I had a degree in agriculture. And repeatedly I have worked in orchards and on farms, and very good ones, too, where it was necessary to keep the fact of a college training a profound secret.

I am glad to note that this tendency is passing and when college courses are so perfected that the graduates are skilled in the simple operations, it will disappear altogether. In the past the department of horticulture has had difficulty in placing Maine students in florists establishments where they could continue their work. Now we have a standing order from two florists who employ about 300 men, to furnish them all the help we can. We are still having difficulty in placing students who want work in nursery practice, but this will pass in time.

What a Student Ought to Know: Just how much to expect of students in the way of practical training it is hard to say, and when an attempt is made to reduce these requirements to writing the task becomes even more difficult. At the University of Maine the various departments

have been trying for two years to agree upon some set formula which can be placed before the students as prerequisites to the regular college work. A tentative outline has been drawn up but never put into practice, for, obviously, if a definite program is to be required, means for securing the information must be provided. At present this has not been possible.

The following list pertaining to horticultural subjects, as applying to New England conditions, is intended to be only suggestive in the hope that a further discussion may work it into a presentable form. These are listed under ten headings:

PREREQUISITES IN HORTICULTURAL PRACTICE WORK.

1. Be able to name, identify and demonstrate the use of the following garden tools:

- | | |
|-------------------|---------------------------|
| 1. Long hoe | 12. Round pointed shovel |
| 2. Wide hoe | 13. Square pointed shovel |
| 3. Cultivator hoe | 14. D handled shovel |
| 4. Hand weeder | 15. D handled spade |
| 5. Hand trowel | 16. Spading fork |
| 6. Garden reel | 17. Manure fork |
| 7. Lawn rake | 18. Hand seed drill |
| 8. Garden rake | 19. Hand dibber |
| 9. Dutch hoe | 20. Sprinkling hose |
| 10. Scuffle hoe | 21. Vegetable scoop |
| 11. Wheel hoe | |

2. To identify from fruit, leaf or wood, the following fruits: 1. Apples, 2. Peaches, 3. Pears, 4. Plums, 5. Cherries, and 6. Quinces.

3. To name and identify the following common flowers and shrubs.

Flowers.

1. Peony
2. Pansy
3. Violet
4. Tulip
5. Narcissus
6. Crocus
7. Hyacinth
8. Dahlia
9. Canna
10. Aster
11. Allysium
12. Snapdragon

Shrubs.

1. Spireae
2. Hydrangea
3. Honeysuckle
4. (Syringa) Lilac
5. Snowball
6. Barberry
7. Snowberry
8. Japanese Rose
9. American Rose
10. Mock Orange
11. Dogwood
12. Privet

4. To name and identify the following vegetables from fruit or plant:

- | | |
|----------------|----------------|
| 1. Cabbage | 14. Onion |
| 2. Cantaloupe | 15. Peas |
| 3. Carrot | 16. Pole bean |
| 4. Cauliflower | 17. Pepper |
| 5. Celery | 18. Pumpkin |
| 6. Beet | 19. Rhubarb |
| 7. Asparagus | 20. Rutabaga |
| 8. Cucumber | 21. Squash |
| 9. Eggplant | 22. Sweet corn |
| 10. Endive | 23. Tomato |
| 11. Kohlrabi | 24. Turnip |
| 12. Leek | 25. Watermelon |
| 13. Lettuce | |

5. Be able to plant the seed and properly tend the plants through the summer of the above list of vegetables.

6. Be able to identify the following weeds:

- | | |
|---------------------|--------------------|
| 1. Black mustard | 12. Ox-eye daisy |
| 2. Wild carrot | 13. Field sorrel |
| 3. Rag weed | 14. Canada thistle |
| 4. Poison ivy | 15. Chickweed |
| 5. Orange hawk weed | 16. Pigweed. |
| 6. Yellow dock | 17. Purslane |
| 7. Burdock | 18. Witch grass |
| 8. Bind weed | 19. Wild lettuce |
| 9. Plantain | 20. Milk weed |
| 10. Bull thistle | 21. Yarrow |
| 11. Dandelion | 22. Buttercup |

7. Be able to identify and give chief methods of handling the following field crops:

- | | |
|---------------|--------------------|
| 1. Field corn | 9. Alfalfa |
| 2. Wheat | 10. Red clover |
| 3. Oats | 11. Mammoth clover |
| 4. Barley | 12. White clover |
| 5. Rye | 13. Crimson clover |
| 6. Buckwheat | 14. Vetch |
| 7. Millet | 15. Timothy |
| 8. Potato | 16. Root crops |

8. Be able to identify the following common trees:

- | | |
|-------------------------|------------------|
| 1. Rock maple | 12. Beech |
| 2. White maple (silver) | 13. Willow |
| 3. Oak | 14. White pine |
| 4. Elm | 15. Spruce |
| 5. Box elder | 16. Larch |
| 6. Gray birch | 17. Hemlock |
| 7. White birch | 18. Balsam (Fir) |
| 8. Poplar | 19. Cedar |
| 9. Linden | 20. Chestnut |
| 10. Locust | 21. Butternut |
| 11. Hazelnut | 22. Walnut |

9. Be able to use, care for and regulate the following farm implements:

- | | |
|------------------------|-----------------------|
| 1. Walking plow | 12. Roller |
| 2. Sulky plow | 13. Grain drill |
| 3. Single cultivator | 14. Potato planter |
| 4. Double cultivator | 15. Corn planter |
| 5. Horse hoe | 16. Grass seed seeder |
| 6. Spike tooth harrow | 17. Corn harvester |
| 7. Spring tooth harrow | 18. Grain harvester |
| 8. Disc harrow | 19. Mowing machine |
| 9. Drag | 20. Potato digger |
| 10. Hay rake | 21. Farm wagon |
| 11. Hay loader | 22. Manure spreader |

10. Be able to handle properly horses or mules in all of the common farm operations:

I do not need to elaborate on this last question as the numerous things that one needs to know in order to properly handle a team will instantly occur to all of you. Some of these things are harnessing and hitching a team to the various tools and adjusting any part that may not fit properly, the proper use of the curry comb, picking up the feet, bedding down, feeding, etc. These can only be acquired by time and practice.

No attempt has been made to outline requirements for other departments than horticulture, although any general plan that is put into operation at any college should take them into consideration. Some of the points enumerated above would overlap when all departments are considered, but these could be easily adjusted to suit all concerned. It would hardly be desirable to include anything in such a list that the average person would not absorb unconsciously by working on a farm for two or three years.

How Secured: In considering this question from the standpoint of time, the practical training may be secured before entering college, during the course, after graduation, or in combination of the three. As to the methods available there are but two, the college and the farm. As both of these have thus far been unsatisfactory some new plan ought to be devised.

As to the time necessary for the student to acquire the practice work, opinions vary. A number of the horticulturists in the Eastern States, whose opinions were secured, placed the minimum at two years and several thought that three would be necessary for the students from the city who have had no opportunity to become familiar with farm life.

It at once became apparent as this investigation proceeded, that life on the farm is necessary for every agricultural student from an entirely different standpoint than the acquisition of practice work. It is necessary to create in the minds of the workers a sympathetic attitude for rural life. This can only be accomplished by contact with the farm and the conditions of the open country. The student out of sympathy with the country is wasting his time by pursuing any course in a college of agriculture.

So important is this sympathetic attitude of mind, that most agricultural college teachers are insisting that the students who elect the associated pure sciences shall have this farm experience. All such subjects as agricultural chemistry, soils, fertilizers, entomology or pathology are most successfully handled by those who know country life. Our experience at the University of Maine will illustrate this point. For two years our teacher of economic entomology was a graduate from the biology department of one of the best universities of the country, but in which no agriculture was given. This teacher was a brilliant student and no fault could be found with his knowledge of the subject. But because he could not connect up his subjects with actual farm conditions the course was a failure. When this man was replaced by an agricultural graduate, although of less training, the course was a success.

The Co-operative Plan: We come now to the real object of this paper, which is to present to you a plan for improving the methods of teaching the practical work in agriculture. This is a co-operative plan to be worked out by the agricultural colleges of several states or groups of states. In brief, this plan is for the states to acquire specialized farms in accredited centers of production. A dairy farm should be provided where dairying is the chief business, from farms where fruit will do well, trucking farms in the trucking sections, and so on. If these could be scattered through ten or twelve states, so much the better. The student then, or any person wanting practical training, could go to these farms and get just what he is looking for. The student could be passed from farm to farm and a broader training and a wider knowledge secured.

Such a series of farms, well coordinated, would satisfy the regular student, the short course man and the city man who wants practical training along special lines. The cost to the student would not be excessive, and his labor would not be a loss to the institution. The work would be conducted not as classes are in the college, but as any foreman would supervise a piece of work. When any student reached a certain efficiency in one line of work he could be passed along to the next and not be held back with the less efficient. When the rounds of all farms had been made the student would then be ready to enter college, or the city man to venture for himself.

Such a plan would not be over expensive to the states, as one farm in each would suffice. This would avoid many duplications and permit of business methods. Less expensive land would be needed at the colleges. Experiment stations would then be able to test out their own recommendations under field conditions. The farms run on a business basis would be partially or perhaps entirely self-supporting. And the large number of students drawn from the wider areas would take care of most of the work.

Some of the results of such a co-operative plan may be indicated as follows: In the first place, it would offer a practical solution of the difficulty in teaching farm work. The results would be satisfactory for all grades of students and for any city person who wanted nothing but the training. The farms would be so specialized that all branches of the work would be covered. The student who had already acquired the work

would not suffer or be handicapped in any way. He could pass through all the branches in a very short time, it being only necessary to demonstrate his efficiency.

The student in passing from one state to another, would come in contact with others in the same line of work from other sections. The diffusion of ideas from different places, would make the students more cosmopolitan and better judges of their own resources. It would broaden and enlarge the horizon of the individual. It would provide an opportunity to observe the methods in the different sections, and the student would be better able to choose the place in which he wanted to live or the kind of work he wanted to do. If this could be required prior to his entering college the experience would be invaluable in helping him to select his major course, or perhaps, convince him that he was not suited to agricultural work and that he had better choose some other career.

The plan would permit of a uniform training for the students through the several states co-operating, and give the small colleges the same advantages as the large universities. It would tend to standardize the methods and practices and give the colleges a better hold upon the rural people, and a larger opportunity in shaping farm policies. And above all, it would place the students above criticism for the lack of ability to perform the simple farm operations.

It would still further tend to simplify the work of teaching after the student enters college. Much of the laboratory work now necessary could be omitted, or the time devoted to advanced studies. Just how much this would amount to varies in the different institutions. In so far as horticulture is concerned, the opinions furnished me vary from nothing to as much as thirty credit hours. A fair average would be about the equivalent of one semester's work. This would mean that the requirements for graduation could be reduced, or rather arts subjects substituted, or more advanced work given in the major departments. It would prevent the necessity of students putting in a lot of time in laboratory work covering ground in which they were already familiar.

In conclusion, it seems evident that some change in present methods is necessary and that the above plan will provide for the difficulties that now exist, and last, that there is no plausible objection why the plan could not be put into operation. It then remains for some organization such as this one to take the initiative and start off the work.

THE PRODUCTION OF SELF-FERTILE MUSCADINE GRAPES.

BY CHARLES DEARING, *United States Department of Agriculture.*

Washington, D. C.

INTRODUCTION.

At the Tampa, Florida, meeting of the society, Professor Reimer read a valuable paper relative to the self-sterility of Muscadine grapes, emphasizing the importance of planting frequent male vines to serve as

pollinizers for the fruit bearing vines. Today it is my pleasure as a representative of the Office of Horticulture and Pomology, United States Department of Agriculture, to present a paper reporting upon the self-fertility of a new race of Muscadine grapes which has been brought into existence as a result of the United States Department of Agriculture's breeding investigations centered at our Muscadine Grape Experiment Vineyard which is located by co-operative agreement at the State Test Farm, Willard, N. C.

PRODUCTION OF SELF-FERTILE VARIETIES.

We consider the production of a new hermaphrodite type of Muscadine grape the most important result of our breeding work. It should be emphasized that at the time the Department of Agriculture began breeding investigations in 1907, there were no self-fertile Muscadine grapes. All the fruiting varieties were self-sterile and dependent on insects to bring fertile pollen from wild staminate vines. Today we have in our breeding blocks approximately 1,000 seedlings of the self-fertile type, and some of these have been propagated, planted in 10 vine checks for further test, and brought to the fruiting stage.

With the production of self-fertile Muscadines four important results have been achieved as follows: (1) Opportunity is now afforded for the first time to intercross within the species without using as one parent staminate vines of unknown fruiting qualities; (2) the size of cluster has been increased, for the self-fertile varieties are the result of perfecting the large-clustered staminate bloom rather than the small-clustered imperfect hermaphrodites; (3) greater productiveness has been secured, for the self-fertile grapes set as berries from 25 to 50 per cent of the bloom buds, whereas, the standard but self-fertile variety scuppernong, for comparison, has set in the same vineyard less than twelve per cent of the bloom buds annually for the last 6 years, because it must rely on insect cross-pollination; and (4) greater vineyard production as well as vine production is now possible, since the hermaphrodites can be planted in place of staminate as pollinators of self-sterile varieties.

The true hermaphrodites have in each blossom a perfect, functioning pistil surrounded by tall, erect stamens containing fertile pollen. The staminate vine blossom has merely a whorl of erect stamens containing pollen. The imperfect hermaphrodites have a normal pistil surrounded by short, generally recurved stamens bearing sterile pollen. With one exception all vines bear only one of these three types of bloom. This one exceptional vine is most interesting in that it is the missing link in the evidence supporting the opinion that the new hermaphroditic type is the result of perfecting the staminate bloom rather than the imperfect hermaphrodite bloom. Examination of the blossoms of this vine shows it to bear blossoms of all stages of gradation from true staminate to true hermaphrodite. In this gradation it is the pistil that varies in development and not the stamens. The stamens are normal and variously developed in all blossoms on the vine. This vine is more decidedly staminate than perfect, but it bore two normal berries containing one and three seeds respectively this autumn. About half of the clusters are staminate and the

other clusters have varying numbers of blossoms with the rudimentary pistil more or less developed. This seedling is one of a series from one pollination operation which also yielded 14 hermaphrodites and 4 imperfect hermaphrodites. In addition to the evidence offered by this vine we have as proof of the fact that our hermaphrodites came from the staminate the following facts: (1) the form of hermaphrodite blossom is like the staminate; (2) the size of hermaphrodite blossom is like the staminate; (3) the profuseness and conspicuousness of the hermaphrodite blossom is like the staminate; (4) on weak hermaphrodite seedlings rudimentary pistils are occasionally found; (5) where imperfect and perfect hermaphrodites have been crossed 50 per cent or more of the seedlings were perfect hermaphrodites and no more vines resulted, but when perfect hermaphrodites and staminate were crossed, staminate, imperfect hermaphrodites, and perfect hermaphrodites resulted; (6) the perfect hermaphrodite like staminate began blooming when very young; and (7) certain strains or groups of seedlings show a tendency toward rudimentary pistils.

It should be of interest to this Society to learn just how we have proceeded in building up this new race of self-fertile seedlings.

The Department of Agriculture began its breeding work in 1907. The crosses that year were made chiefly in a commercial vineyard at New Smyrna, Florida, which contained the largest collection of varieties then in existence, and was surrounded by quantities of native vines of *V. munsoniana* and *V. rotundifolia*, the two series constituting the *Muscadinia* group. In the same year, following the Florida work, other crosses were made at several places in Georgia, South Carolina, and North Carolina, where desirable material had been located. The seedlings resulting from this work were propagated in Washington and planted in the experiment vineyard at Willard, North Carolina, as the first seedling vineyard. Later when these seedling vines began to fruit and bloom, two of them were found to be true hermaphrodites, perfect-flowered, and self-fertile, whereas the other seedlings and all other Muscadine grapes were either staminate or imperfect hermaphrodites. The two original true hermaphrodites will be designated as H¹ and H² in the following discussion: H¹ was the result of a cross at New Smyrna, Florida, between the standard self-sterile variety Eden and a wild, dark type, staminate, *V. musoniana* vine. H² was the result of a cross at Medoc Vineyard, Enfield, N. C., between the standard self-sterile variety Scuppernong and a light type staminate vine. A large number of the seedlings were of the same parentage as the two hermaphrodites, but staminate or self-sterile, like other Muscadines. From the two original hermaphrodites other hermaphrodites have been produced, but the Department of Agriculture did not succeed in producing a third hermaphrodite of distinct parentage until this season. As a result of a cross made in 1913 between two seedling vines in the Muscadine Grape Experiment Vineyard at Willard, North Carolina, a third hermaphrodite of distinct parentage has been produced. This vine, H³, began blooming during the past season, 1917, and bore a fair crop of medium size, bronze colored berries in medium size clusters. It is a vigorous vine and has set fruit readily under paper bags. Its pollen germinates vigorously in sugar solution. It has been successfully used to pollinate the standard varieties of other hermaph-

rodites, and it has been successfully pollinated with pollen from staminate and other hermaphroditic vines during the past season.

Of the two original hermaphrodite seedlings, H¹ is *V. munsoniana* in type, while H² is entirely *V. rotundifolia*. The former has small black berries in relatively large clusters, while the latter has large light colored berries resembling Scuppernong fruit, though not equal to Scuppernong in quality. The self-fertility of the latter is more pronounced.

Having produced the two original hermaphrodites, the next step was to multiply the type and to transmit the hermaphroditic character to other seedlings. H¹ produced a little bloom in 1911. In addition to using this to test the seedling itself (i. e., its pollen, pistils, and fruit), sufficient bloom was secured to pollinate two clusters of Eden, its female parent. This cross yielded two fruit clusters, one of eight berries and one of twenty-two berries, from which 154 seeds were secured. From these, fifty-four seedlings are now living and fruiting. Thirty of these (over 55 per cent) are self-fertile hermaphrodites and the rest imperfect hermaphrodites. Apparently the seedlings which, in a normal Muscadine cross, would be staminate are in this case hermaphrodites, or figuratively, pistils have been inserted in the staminate blossoms making true hermaphrodite blossoms. These seedlings are as a group intermediate between their parents. The best are very prolific, large-clustered, with average-size black berries of good vinous flavor and good quality. They are closely similar and fully equal to Eden, and in addition have the hermaphrodite character. The better representatives are being used as parents in the breeding investigations.

After being used in 1911, H¹ was killed to the ground during the severe winter of 1911-12, but resprouted and has not since shown injury. Vines propagated by cuttings from it are now fruiting in the variety collection.

In 1912 sufficient pollen of H² was available to permit limited crossing, from which one Scuppernong cross, seven James crosses, and five selfed crosses, are now fruiting. The seedling of Scuppernong parentage is an imperfect hermaphrodite, but subsequent crosses have shown that this was merely chance. Had there been more seedlings produced, some would undoubtedly have been hermaphrodites. Of the seven James crosses, three are hermaphrodites and four imperfect hermaphrodites. One of the hermaphrodites is of the dark type and very similar to James in fruit quality, while the other six seedlings are of the light type, bearing light fruit. The two light hermaphrodites are much like James in habit, but light-fruited. We thus have not only a hermaphroditic equivalent for James in the dark seedling, but in the other two a new type which can be described as a hermaphroditic, light-fruited combination of James and Scuppernong. Of the five self-pollinated seedlings of H², all are of the light type, all hermaphrodites, all markedly self-fertile, and all very similar to the parent.

In 1913 sufficient bloom was produced on H² to pollinate the leading varieties, and some of our best self-sterile seedlings. The object of this work was to produce hermaphrodites so nearly resembling the present leading varieties in fruit qualities as to permit substitution, and also to produce hermaphroditic combinations between the standard variety

types. During the season of 1916, the seedlings resulting from this 1913 work began fruiting, and the results, while not all that might be desired, are very encouraging. In addition to some new fruit-type seedlings having the hermaphroditic bloom character, we have apparently now what might be characterized as James, Scuppernong, Thomas, Eden, and Flowers hermaphrodites.

In 1914 a considerable number of crosses were made, using H^2 , H^1 , and the better hermaphroditic progeny of H^1 . Additional work was done in 1915. The resulting progeny began blooming and fruiting this year as two-year-old seedlings. Approximately 85 per cent of these seedlings which began blooming this season have proved to be self-fertile hermaphrodites, and a wide range of fruit characters is represented in the collection. It is certain that by the time the remaining seedlings in this lot have begun blooming next season, we will have over 1,000 hermaphrodite seedling varieties, the best of which are in fruit quality fully equal to our present varieties in quality, and superior to them in size of cluster and productiveness. I prophesy that in the near future it will be entirely possible to discard our present self-sterile standard fruit varieties and substitute for them, not only varieties of self-fertile hermaphrodite type which are almost identical in fruit and vine characters, but also other hermaphrodites presenting new characters of fruit which combine the best qualities found scattered among our present varieties. If we are successful in achieving these results, the Muscadine grape industry is assured of a very flourishing future.

ANNUAL MEETING AT PITTSBURG, PA., 1917

THURSDAY, DECEMBER 27, 9:30 A. M.

President Johnson presided over the meeting. Owing to congested railroad traffic, war conditions generally, and personal reasons, the attendance was very light, only 35 members being present. The program was especially good, and it is to be regretted that a full attendance was not possible.

METHODS IN PURE LINE SELECTION WORK WITH POTATOES.

By O. B. WHIPPLE, *Montana Experiment Station, Bozeman, Mont.*

If we accept the term in its common usage, a pure line among potatoes is a strain established either by hill or tuber unit selection. Both methods of isolating pure lines have been frequently used and probably more frequently advocated. Either is satisfactory as a means of establishing these so-called pure lines, provided, that in the case of selected hills, single stem hills be chosen. From an experimental viewpoint the use to which the pure line is to be put may determine which system of

selection it is best to follow. If the purpose is simply to establish a pure line as a reliable seed basis for general experimental work, the hill is probably the most promising starting point, for it has greater possibilities in rapid increase. If the purpose is to study the comparative yielding powers of pure lines within a variety, with the idea of establishing high-yielding strains, we believe the tuber unit system has some advantages.

We believe pure line selection work merits more careful attention from those interested in potato improvement. It is safe to say that more satisfactory results would follow if pure line seed were used as a basis for all comparative potato tests. On the other hand, it is very, very doubtful whether we appreciate the possibilities or the limitations in potato improvement through pure line selection. There is still need of much careful work before the case is really ready for the court. The methods here set forth are the outgrowth of some four years of effort along the line of potato improvement, years of effort which have really yielded, not so much in the way of improvement, as a better understanding of the problems involved. At the present time, we are interested, first, in whether high-yielding pure lines do or do not commonly exist within the population of our potato varieties, and, second, in the stability of desirable characteristics exhibited by pure lines when first isolated.

SEED SELECTION.

Our early experience with pure lines were with some isolated by hill selection. But in this work we always seemed to lack in numbers. Possibly our ideals were too high, but we could not secure a sufficient number of hills measuring up to our standards to carry on a really satisfactory test. So, partly due to the labor involved in selecting hills, partly on account of disappointments over the behavior of the progeny of these hills, but chiefly from a desire to work with numbers, we have discarded hill selection for the simpler method of establishing pure lines by choosing tuber units. Within pure lines we practice mass selection, making special effort to select seed representing so far as is possible the entire plot and not the best hills within the plot or pure line. We believe that the real test can only follow mass selection within the pure line, and that we have not demonstrated the existence of high-yielding strains within the population of a variety until we have proven that high-yielding lines can be maintained by mass selection.

CUTTING THE SEED.

Size of seed piece is a factor that must be considered in potato tests and in our pure line work we have practiced planting seed pieces of uniform size. Selected tuber units were first cut to a uniform weight and then quartered, giving four seed pieces not necessarily uniform in weight but equal in weight to each group of four pieces included in the tests. More recently we have designed a cutting tool which greatly facilitates the cutting of uniform sized seed pieces. This is a tool patterned somewhat after one commonly used for cutting potato balls used in cookery.

It cuts a seed piece practically hemispherical in shape with a diameter of one and one-fourth inches and a depth of three-fourths of an inch. In actual practice, seed pieces cut with this tool averaged about eleven grams, or approximately one-third of an ounce, in weight. Groups of twenty seed pieces varied not to exceed fifteen grams in total weight, or three-fourths of a gram per seed piece. This variation in weight was in the main due to variation in depth of eyes. While the size of the seed piece may seem small, a larger cutter could not be designed to cut tubers to good advantage. Under our system of planting, these small single-eye seed pieces have given just as satisfactory results as larger seed pieces planted in field practice. The fact that groups of twenty hills have yielded 84 pounds of marketable tubers, or at the rate of 39,000 pounds per acre, would indicate that the small seed piece has not been a serious handicap.

SIZE OF PLOTS.

We adopted twenty hills or twenty-five feet of row as the standard size of plot after the first year. While larger plots may be desirable, we consider it of greater importance to test a large number of pure lines, and have cut the size of plot to what we consider a satisfactory minimum.

ARRANGEMENT OF PLOTS.

At the present time this station has under test 108 pure lines each, of Green Mountain, Rural New Yorker and Early Ohio. These are tested under numbers running from 300 to 624. They are planted consecutively in ranges varying from 9 to 12 plots long, and 9 to 12 rows wide, the arrangement being varied somewhat from year to year so certain lines do not always fall side by side in adjacent rows. We believe that this shift in arrangement furnishes a valuable check on soil variation. The check plots consist of a single row of each of the three varieties under test, placed near the center of the range of the corresponding pure lines. This row is of the same length as the range of plots. The pure line test block is surrounded by marginal plantings so that growing conditions may be uniform. This is, we believe, important. Not only will outside rows yield more than inside rows, but data secured at this experiment station indicate that, other things being equal, seed from such rows has higher yielding powers than seed from inside rows.

DUPLICATE OF SINGLE PLOT TESTS.

We favor single-plot tests, and at present our work is being carried on in this manner. We believe that such tests continued over several seasons will give just as reliable results as duplicate or triplicate tests conducted over a shorter period. Again, when plots are duplicated or triplicated we are confronted with a more difficult problem in seed selection. It is not fair to select seed from one of the plots, and it is very hard to select a small composite sample which will fairly represent the line. Duplication of plots really involves the saving of seed from each plot and the testing of this seed, not as a composite sample, but in

separate plots. Thus it seems to us that the duplication of plots tends to complicate the interpretation of results without offering any real advantages when compared with single-plot tests carried on over a long period of years.

PLANTING.

Pure lines are planted in rows three feet and nine inches apart, and in hills fifteen inches apart. Depth of planting is carefully gauged at three inches. Planting is accomplished with the aid of a planting board twenty-five feet long and containing twenty $1\frac{1}{2}$ inch holes spaced fifteen inches apart, and a dibble. The dibble is provided with a shoulder which allows it to be pushed down through the holes to a fixed depth. The seed is then dropped in the hole and covered before the board is removed. The end holes are placed seven and one-half inches from the end of the board so a series of units represents a solid row with hills fifteen inches apart.

CULTURE.

Pure line test plots receive culture similar to that given field stock with the exception that hills are thinned to single stems. This thinning is done as soon as the vines are large enough to pull. On account of variation in the number of stems produced even by single-eye seed pieces and the direct influence of number of stems upon yield, it would seem more reliable to compare yields of hills with a uniform number of stems.

RECORDS.

The first record made is a plot showing the arrangement of the pure lines in the field. Such an annual record is important, we believe, and it will be found of great value in interpreting results. The usefulness of such a record is represented in the chart showing the relative position of the twenty highest and twenty lowest yielding (the latter in italics) pure lines of Rural New Yorker under test at the Montana Experiment Station in 1917. This chart indicates how well soil variations are brought out by such records. In the final summing up of tests of this kind where all the factors must be considered, we believe such an annual record will be found indispensable.

Careful field notes are kept on the behavior of pure lines as indicated by growth and vine characteristics. These notes are of value in many ways, but we find them particularly useful in locating so-called degenerate types and following their performance throughout the test. Not only are we studying those lines that show degeneracy from the beginning, but we are watching for the appearance of degenerate plants within all pure lines. Growth records should note particularly comparative vigor of pure lines, uniformity of plants within pure lines, character of foliage (whether normal or abnormal for the variety) and the uniformity of foliage characteristics within pure lines.

Records must be kept of percentage of stand as, on small plots, yields cannot be computed justly without them. We believe also that we must go beyond recording the percentage of stand, and record the positions of missing hills. While at present we are computing yields upon the basis of 100 per cent stand we are sure this is not quite fair and we are in hope

AMERICAN SOCIETY FOR HORTICULTURAL SCIENCE.

CHART SHOWING LOCATION OF 20 HIGHEST YIELDING PURE LINES
AND 20 LOWEST YIELDING PURE LINES (THE LATTER IN
ITALICS). TEST 108.

VARIETY—RURAL NEW YORKER—SEASON 1917.

			412	413		415		
418			421	422		424		
	428			431	432	433	434	
	437					442	443	
	446	<i>447</i>				451	452	453
<i>454</i>		<i>456</i>						
<i>463</i>								
			Check	Row				
<i>472</i>	<i>473</i>							
481	482	483	484		486	487	488	489
490			<i>493</i>		495			
						505	506	
		510						<i>516</i>

of working out a more equitable method. Figured on the basis of 100 per cent, missing hills tend to raise the yield for adjacent hills are benefited by vacancies. But three adjacent vacancies will not have the same influence as three scattering ones, hence, the necessity of a record showing the arrangement of stand until we have arrived at some basis of estimating how much hills bordering on vacancies are benefited.

We have practiced keeping a record of the number of tubers produced, both marketable and culls, and the weight of tubers, both marketable and culls. As we are working with a large number of pure lines, we have made no effort to study tuber characteristics of individual selections other than to note exceptional characteristics exhibited by certain lines.

SOME CORRELATIONS IN POTATOES.

BY WILLIAM STUART, *United States Department of Agriculture,*
Washington, D. C.

The correlations upon which this paper is based are the result of studies which have been carried on by the office of Horticultural and Pomological Investigations in the United States Department of Agriculture, during the past three seasons, 1915-1917. The data which are presented are the results of careful studies of the performance of plants produced from whole and cut seed of various sizes. The size of tubers used in the experiment varied by ounce graduations from 6 to 1½. The Irish Cobbler variety was selected for this study, because it is the variety that is almost exclusively grown as an early crop north of Florida, in the Atlantic Coastal Plain section.

Before proceeding further with our discussion, it is perhaps desirable to add by way of explanation that we do not claim to have made any new discoveries, or, for that matter, to have added much to the subject that was not already known. Our object is rather to present the information that we have secured in a somewhat different manner than any that has heretofore come to our attention. Much of the experimental work that has been conducted on the size of seed piece has been carried on with a too limited number of plants to make the results secured of as great a value as could be desired from a purely experimental point of view. There are, however, two notable exceptions to this criticism which are deserving of mention in this connection.

These are the contributions of Aicher¹ and of Welch², which were published in Volume 9, of the Journal of the American Society of Agronomy, pp. 217-230, inclusive.

The results secured by Aicher and Welch are in the main very similar to those which are presented in this discussion, but as has been previously mentioned, the data are not handled in quite the same manner.

PLAN OF THE EXPERIMENT.

In order to secure a uniform lot of tubers of the various sizes studied, they were separated by careful weighing into groups of 6, 5, 4, 3, 2 and 1½ ounces. The variation in either direction from the sizes mentioned did not exceed 5 grams.

Several hundred tubers were included in each lot. Each of these carefully weighed groups was then separated into three lots, the first of which was planted whole, the second halved, and the third quartered before being planted. By planting these different sized seed pieces in adjacent rows, it was possible to make a very careful comparison between

1. Aicher, L. C. "Whole vs. cut Potato tubers for planting on irrigated land." *Journal of the Am. Soc. of Agron.* 9:217-223, 1917.

2. Welch, J. S. "Whole vs. cut potato tubers for planting on irrigated land." *Journal of the Am. Soc. of Agron.* 9:224-230, 1917.

the plants and tubers produced by each row. This plan was followed with the other sized tubers. In 1915 the experiment was planted in duplicate, and in 1916 and 1917 in triplicate. Each of the rows was exactly 8 rods in length. In 1915, the seed pieces were spaced 14 inches apart in the row, while in both 1916 and 1917 they were spaced 16 inches apart. In the Norfolk experiment, the rows were always spaced a meter apart rather than the more common spacing of 34 inches. In Maine, the spacing in the row in 1916 and 1917 was the same as at Norfolk, but the row spacings were 34 and 36 inches, respectively.

With such a uniform lot of tubers, so far as size goes, it was felt that any variation in the number of stems per plant, or tubers per plant, and in the resultant yield of marketable potatoes, would be wholly due to the influence of the size of the seed piece used. The data taken in 1915, 1916 and 1917 included the number of stems per plant and the number and weight of tubers produced by each individual plant. The data taken on the tubers of each plant in 1915 consisted in separating them into two lots. All those weighing above 65 grams (approximately 2 1/3 ounces) were classed as primes, or marketable potatoes—the remainder being disposed of as culls. In 1916 and 1917 the tubers from each plant were separated into three lots. The first lot, or primes, consisted of tubers weighing over 85 grams (3 ounces); the second lot, or intermediates, included tubers weighing between 65 and 85 grams; and the third, or culls, those below 65 grams.

The establishment of the intermediate size was made necessary in order to conform to what was thought desirable data to take on the same experiment as conducted in northern Maine. For example a 3-ounce potato in Aroostook County, Maine, should be considered the minimum weight permissible in table stock, whereas in the early trucking regions of the South a 65 or even a 50 gram tuber would, in most seasons, be regarded as a prime or merchantable tuber.

STEM CORRELATION.

The correlation between size of seed used and the number of stems produced is strikingly consistent throughout, as is indicated by the 1915 and 1916 crop at Norfolk, Virginia, and Presque Isle, Maine, and is shown in Table I.

A careful study of these data shows a very marked uniformity in the average number of stems produced from the same sized seed piece in the two seasons at Norfolk. The Maine data, though somewhat less uniform, are on the whole sufficiently corroborative to furnish convincing evidence that the size of the seed pieces bears a direct and proportional relation to the number of stems produced.

The data also show quite clearly that the same sized seed piece planted in Maine produces a larger number of stems than it does at Norfolk. An average of the results secured from comparable data for both seasons shows that the Norfolk plants produced 2.89 stems, while the Maine plants had 4.05 stems per plant. The only explanation that can be offered for this 40 per cent increase in number of stems of the Maine-

TABLE I.

Average number of items per plant from different sized seed, as grown at Norfolk, Virginia, and Presque Isle, Maine, 1915-1916.

Size of Seed	1915 Norfolk average number of stems	1915 Maine average number of stems	1916 Norfolk average number of stems	1916 Maine average number of stems
6 oz. whole	5.07	6.93	5.80	7.97
6 " halved	3.02	4.27	3.06	4.94
6 " quartered	1.98	2.26	1.96	2.67
5 " whole			5.13	7.31
5 " halved			2.99	4.52
5 " quartered			1.80	2.69
4 " whole	4.38	5.59	4.37	6.25
4 " halved	2.73	3.87	2.45	3.90
4 " quartered	1.74	2.12	1.56	2.35
3 " whole	3.50	4.71	3.47	5.19
3 " halved	2.28	3.94	1.91	3.32
3 " quartered		1.80	1.43	2.15
2 " whole	3.02	3.52	3.09	4.09
2 " halved	2.00	2.62	1.93	2.33
1½ " whole	7.00		2.26	

grown plants, is that the extremely early planting at Norfolk puts the seed in the ground long before the soil has warmed up and before the weaker sprouts have been stimulated into growth, before the seed is planted. In Maine, on the other hand, planting is usually deferred until the middle or latter part of May, when the weather and the soil have begun to grow warm and the seed to begin to germinate. Under the latter conditions, it is reasonable to expect a larger number of eyes to start into growth. It is also interesting to note the behavior of whole, halved, and quartered seed. Take, for instance, the 6-ounce tubers, the averages for the 6-ounce whole, are 5.07, 6.93, 5.80, 4.97, or a combined average of 6.44 stems per plant; the 6-ounce halved runs 3.02, 4.27, 3.06 and 4.94, or a combined average of 3.82; and the 6-ounce quartered, 1.98, 2.26, 1.96, 2.67, or a total average of 2.22 stems per plant.

TUBER CORRELATIONS.

The data secured show as striking a correlation between the size of set planted and the resultant tubers produced, as has been noted in the case of the stems. Only such data are presented as will suffice to illustrate the point in question.

The Norfolk 1916 data show the following tuber averages per plant:

6 ounce whole,	19.81;	6 ounce halved,	12.09;	6 ounce quartered,	9.65
5 " "	19.15;	5 " "	11.88;	5 " "	9.23
4 " "	16.11;	4 " "	10.91;	4 " "	8.57
3 " "	13.63;	3 " "	10.65;	3 " "	8.51
2 " "	12.54;	2 " "	9.11;		

A study of these data shows a difference in number of tubers produced from the 6 ounce and 2 ounce whole seed of 7.27 per plant, or a decrease of nearly 38 per cent. The 6 ounce halved seed shows a variation of 2.98, or nearly 25 per cent; while the quartered seed showed only a variation between the 6 ounce and 3 ounce quartered, of about 13 per cent.

PRODUCTION CORRELATIONS.

The question as to whether it is advisable to use whole or cut seed is dependent on whether the use of an additional amount of seed produces a sufficient increase in yield to justify the added cost of the seed. In some sections, and with some varieties, it may be a good practise to plant whole seed, while in other sections, and with other varieties, it may not be desirable. The data presented in Table II give the yield of merchantable tubers and of merchantable and unmerchantable combined for the years 1915 and 1916 at Norfolk, and 1916 in Maine.

A careful study of the yields secured in 1915 and 1916 at Norfolk shows a very wide difference in the two seasons, the 1916 yields being nearly double those of 1915. This was particularly true with respect to merchantable tubers.

In our opinion, this result is largely if not entirely due to the different character of the growing seasons of 1915 and 1916. The season of 1915 was dry throughout much of the growing period and in consequence thereof the yield was very materially reduced. This opinion is amply substantiated by a comparison of the data:

In 1915 the crop from the 6 ounce whole tubers averaged 220.4 bushels per acre. In 1916, it averaged 464.8 bushels, or over 100 per cent greater. In 1915, the 6 ounce halved yielded at the rate of 270.8 bushels per acre, while the 1916 crop yielded 420 bushels. The 6 ounce halved in 1916 yielded over 50 bushels per acre more than the whole seed, while in 1916 the halved seed yielded over 44 bushels less than the whole seed, a direct reversal from that of 1915.

The answer to this is that the more favorable growing season of 1916 afforded suitable conditions for the development of a larger proportion of merchantable sized tubers, from the whole tubers, than in 1915. It

TABLE II.

Yield in bushels per acre of merchantable and total tubers, 1915 and 1916.

Size of Seed	1915 Norfolk		1916 Norfolk		1916 Maine	
	Merchantable Bushels	Total Bushels	Merchantable Bushels	Total Bushels	Merchantable Bushels	Total Bushels
6 oz. whole	220.4	329.2	464.80	558.12	206.06	405.29
6 " halv'd	270.8	327.9	420.43	466.36	184.55	343.73
6 " q't'd	245.8	289.1	368.50	403.81	193.00	294.59
5 " whole			449.43	540.78	212.05	389.37
5 " halv'd			414.43	460.65	219.97	339.78
5 " q't'd			366.68	403.79	213.22	300.61
4 " whole	259.2	338.4	413.18	490.48	248.13	359.92
4 " halv'd	276.7	324.2	383.83	429.17	216.61	344.01
4 " q't'd	232.9	270.4	357.65	390.37	238.62	304.87
3 " whole	264.2	332.5	410.45	467.33	182.03	350.50
3 " halv'd	230.8	270.8	402.91	440.41	201.56	307.38
3 " q't'd			377.01	403.68	213.19	262.01
2 " whole	221.7	278.8	331.14	393.34	160.45	289.44
2 " halv'd	220.0	256.7	305.73	342.58	246.16	329.48
1½ " whole			313.73	352.25		

has already been noted that the 6 ounce whole seed produced over 63 per cent more tubers than did the 6 ounce halved seed. Hence, under favorable conditions, whole seed may be expected to produce a heavier yield than cut seed. There is, however, another factor which must be taken into consideration, and that is the cost of the seed. For example, planted on the basis of the Norfolk and Maine experiments, it required 10,000 sets, or seed pieces, to plant an acre. At this rate, the following number of pounds of seed would be required to plant an acre:

6 ounce whole,	3750.00	pounds, or 62.50 bushels
6 " halved,	1875.00	" " 31.25 "
6 " quartered,	937.50	" " 15.63 "
5 " whole,	3125.00	" " 52.08 "
5 " halved,	1562.50	" " 26.04 "
5 " quartered,	781.25	" " 13.02 "
4 " whole,	2500.00	" " 41.67 "
4 " halved,	1250.00	" " 20.83 "
4 " quartered,	625.00	" " 10.42 "
3 " whole,	1875.00	" " 31.25 "
3 " halved,	937.50	" " 15.63 "
3 " quartered,	468.75	" " 7.81 "
2 " whole,	1250.00	" " 20.83 "
2 " halved,	625.00	" " 10.42 "

If we deduct this amount of seed from the yield of merchantable tubers, which, in our judgment, is where the deduction should be made, we have the yields shown in Table III.

TABLE III.

Corrected yield in bushels per acre of merchantable tubers 1915 and 1916.

Size of Seed	Norfolk		Maine
	1915 merchantable bushels	1916 merchantable bushels	1916 merchantable bushels
6 ounce whole	157.9	402.3	143.6
6 " halved	239.6	389.2	153.3
6 " quartered	230.2	352.9	177.4
5 " whole		397.4	160.0
6 " halved	239.6	388.4	193.9
5 " quartered		353.7	200.2
4 " whole	217.5	371.5	207.5
4 " halved	255.9	363.0	195.8
4 " quartered	222.5	347.2	228.2
3 " whole	233.	379.3	150.8
3 " halved	215.2	387.3	185.9
3 " quartered		369.2	205.4
2 " whole	200.9	310.3	139.6
2 " halved	209.6	295.3	135.7

A careful study of these yields again emphasizes the fact that in very favorable seasons, the larger the size of the seed used, at least up to six ounces, the greater will be the resultant yield, and that under unfavorable growing conditions such as prevailed at Norfolk in 1915, and in Maine in 1916, the cut seed, as a rule, gave the best results.

SUMMARY.

The data presented in this paper can be briefly summarized as follows:

1. There is a direct correlation between the number of stems and the size of seed piece used. The average number of stems is uniformly proportional to the size of the seed piece used.

2. There is an equally direct correlation between the size of the seed tuber used and the average number of tubers produced.

3. The resultant yield from the use of large or small sized seed pieces is more largely dependent on climatic conditions and soil fertility than on the size of the seed. With optimum growing conditions, the yield seems to be proportional to the size of seed used, and disproportional to it if the growing conditions are unfavorable.

BORDEAUX SPRAYING FOR POTATOES IN THE CORN BELT.

By A. T. ERWIN, *Iowa State College, Ames, Iowa.*

The Corn Belt region possesses a soil and climate peculiarly its own. Plant diseases are intimately related to these two factors and consequently the foliage diseases of the potato in this territory present a distinct problem as to their life history and methods of control.

The deductions made in this paper are based upon investigations, conducted by the speaker during the past five years, at the Iowa Experiment Station. They represent typical corn belt conditions in the Upper Mississippi Valley, the heart of the corn belt.

The foliage diseases of the potato which are more or less prevalent in this region and for which bordeaux mixture is commonly recommended are late blight, early blight, and tip burn.

LATE BLIGHT.

At least three¹ pronounced outbreaks of late blight, *Phytophthora infestans*, have occurred in Iowa in the past half century. This disease is more or less common throughout the Upper Mississippi Valley from which the corn belt receives its seed supply and is, therefore, probably introduced into some portions of this territory every year. Under normal climatic conditions it does not survive even when so introduced, and yet in occasional years it breaks forth in a virulent form.

In parts of the New England States late blight is usually present, but fails to develop only in dry years. In the corn belt conditions are reversed. It is usually absent and its presence in every known instance has been accompanied by abnormally wet weather and low midsummer temperatures, of which the season of 1915 is an excellent example. The loss in the years of these epidemics has been heavy. The majority of growers recognize this fact and also concede the value of bordeaux mixture for its control. However, since its re-currence is at a decade and one-half intervals and the potato crop rotates with corn and clover, the general disposition of the grower is to take his chance on late blight rather than to insure against it.

EARLY BLIGHT.

In the corn belt early blight, *Alternaria solani*, commonly makes its first appearance as a saprophyte, following tip burn and flea beetle injury.

¹ Erwin, Bulletin 163, Iowa Experiment Station, April, 1916.

Early blight flourishes during a cool season and does not commonly appear in central Iowa until past midsummer. In the cooler parts of the United States it usually appears earlier than this and also in advance of late blight, hence, the term "early blight." Under corn belt conditions the term is really a misnomer, but is adhered to for the purpose of avoiding confusion because it has been so widely used in potato literature.

Unlike late blight, early blight is comparatively slow in development. The mycelium can often be found in the vines two to three weeks in advance of its appearance. Though present, it is held in check by high temperatures and low humidity. With the advent of the cool fall weather and heavy dews its growth is encouraged.

Under average conditions early blight may be expected in central Iowa any time after the middle of August, and is usually not very common before that period.

By this date the early varieties, such as the Early Ohio, which is so widely grown in this region, and the midseason sorts, such as the Irish Cobbler, are ready to harvest. Over much of the corn belt region the attack of early blight is, therefore, largely restricted to the late varieties, principally the Rural New Yorker. On this variety it can usually be found on the foliage during the early autumn, but to such a limited degree as to be of little economic consequence.

TIP BURN.

This is the one very generally present foliage trouble of the potato here. It appears in midseason when the plant is taking up the work of starch making in the new tuber, and hence very seriously impairs the efficiency of the foliage system at a most critical period. Tip burn, under average conditions in the corn belt, probably does more to reduce the potato yields than all of the other foliage diseases combined. It is due to transpiration being in excess of absorption. It is probably influenced in a measure by soil moisture conditions, but is fundamentally a climatic relationship.

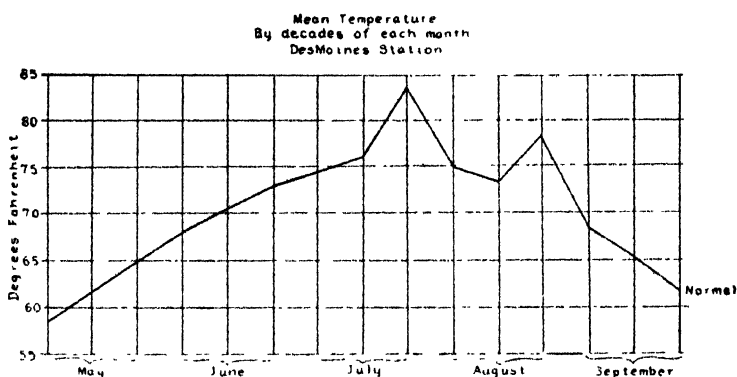
CLIMATIC CONDITIONS WHICH CAUSE TIP BURN.

A study of the climate for the summer months presents some important facts as to the cause of tip burn and the conditions which induce it in the corn belt.

The important factors affecting transpiration, are temperature, rainfall, humidity, and sunshine.

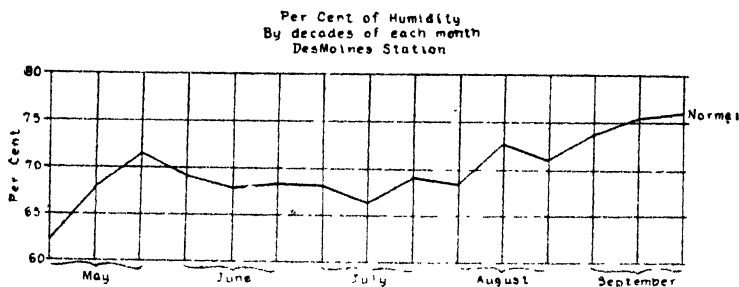
THE TEMPERATURE RELATION.

In Chart I are shown the normal maximum temperatures for the growing season of the potato in Iowa. It will be noted that the temperature for June is relatively low and that the high temperatures for the summer are reached during the third decade of July. It is during this period of sweltering heat with a mean upwards of 85° F. that the corn crop jumps and the potato lags.



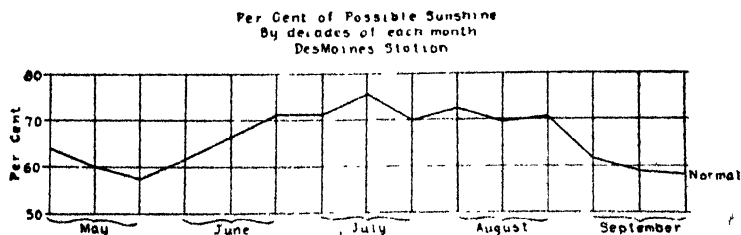
HUMIDITY.

A study of humidity, Chart II, indicates a condition the reverse to that of temperature. The low point for the summer is reached during the second decade of July from which time there is a gradual rise to the end of the season.



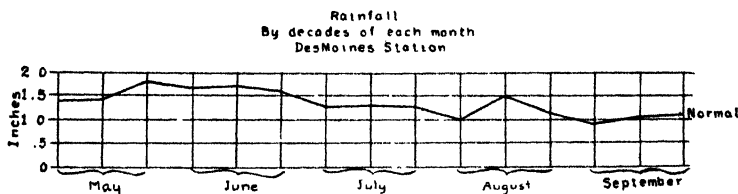
SUNSHINE.

The percent of possible sunshine, Chart III, is relatively low for May and September and reaches its maximum during July and August.



RAINFALL.

The rainfall, Chart IV, is heaviest during the period covered by the third decade of May and the month of June. July and September are



relatively dry months with a decided increase in precipitation during the second decade of August.

It will therefore be noted that July and early August present a serious combination of unfavorable climatic factors for the potato. This period is characterized by low humidity, scant rainfall, high temperatures and maximum sunshine.

The ability of the plant to withstand adversities is in a measure determined by its previous condition. The climate for the month of June, from the standpoint of humidity, rainfall and temperature, is such as to induce a vigorous, sappy growth. Hence the plant is illy prepared for the dry, hot weather and low humidity of July and early August. The giving off of moisture is in excess of root absorption during this period. As a result, the marginal leaf cells collapse and die, producing tip burn.

These conditions make corn and unmake the potato crop. The success of late varieties is largely a matter of tiding over this period and making a prompt recovery with the advent of cool weather and fall rains.

SUSCEPTIBILITY OF VARIETIES TO TIP BURN.

The two varieties most widely grown in the corn belt are the Early Ohio and Rural New Yorker. The Early Ohio is a plant of rather weak constitution, sparse foliage and very susceptible to tip burn. The Rural New Yorker is a vigorous plant with a rugose leaf peculiarly adapted to corn belt conditions. Of a very large list of varieties tested on the Iowa Experiment Station grounds, the Rural New Yorker is outstanding for heat endurance combined with other necessary qualities of a commercial potato. Mr. Carmen deserves a lasting monument for his contribution in giving us this variety.

BORDEAUX APPLICATIONS.

With the increasing cost of production, all operations pertaining to the growing of the crop are being scrutinized as never before. The grower therefore asks, what are we spraying for?

Late blight occurs only at wide intervals. Early blight is usually of little consequence. The one important thing then is tip burn.

Bordeaux spraying to justify itself on a field basis in potato production in the corn belt must make good first of all as a preventative of tip burn.

It is not, therefore, a question primarily of applying a fungicide, but rather of a physiological response from the use of copper salts for the purpose of reducing transpiration.

The value of bordeaux for this purpose has been clearly established under certain climatic conditions.

Lutman¹ of Vermont, in discussing the use of bordeaux in a season in which fungous troubles are not present, says "Bordeaux mixture increases the yield from potato plants by the prevention of tip burn and flea beetle injury. When plants which are not troubled by tip burn or flea beetle are sprayed, yields are not increased." Similarly, beneficial results from the use of bordeaux in preventing tip burn are reported by Stewart² of the New York Agricultural Experiment Station.

The general trend of field evidence under eastern conditions strongly indicates the value of bordeaux for this purpose and also as a stimulant causing a greener and more luxuriant growth of foliage.

On the other hand, laboratory studies seem clearly to indicate that bordeaux applications actually increase transpiration. Thus spraying might seem to have a tendency to increase rather than check tip burn and its use in regions of a dry atmosphere where tip burn is normally severe might prove a detriment rather than a benefit.

Duggar and Cooley³ found that a film of bordeaux facilitate transpiration.

Martin⁴ reports that "in every instance the sprayed leaves showed signs of wilting at some period preceding the time at which the unsprayed leaves of the same species began to wilt. This is only what would be expected in view of the fact that the average rate of water loss from the sprayed leaves is nearly double that from the unsprayed leaves during the experimental time period." Martin⁵ also found that the influence of bordeaux on the rate of transpiration becomes effective immediately after the spray dries on the leaves. The highest average increase occurs during the first two-hour period following an application of the spray.

Thus on the one hand we have the field evidence favoring the use of bordeaux to prevent tip burn and the experiments of the laboratory on the other hand leading to a contrary conclusion.

In the period of the Iowa experiments, the foliage conditions on the sprayed and unsprayed plots were carefully studied. On the one hand the use of bordeaux did not show the marked results as a specific for tip burn that followed its use in the above-mentioned experiments in eastern states. On the other hand, at no time was there evidence that it increased tip burn, or was otherwise injurious. Whatever difference there was between the sprayed and check plots was distinctly in favor of those treated. This was true both from the standpoint of yield and foliage conditions. Furthermore, the results were cumulative and the highest total yields came from the plots receiving the greatest number of applications.

1. Bull. Vt. Agrl. Exp. Sta., 196:4

2. Bull. N. Y. Agrl. Exp. Sta., 311:37.

3. Mo. Bot. Gard., 1: 1:22; 351-356.

4. Journ. Agrl. Res., 8:586.

5. Journ. Agrl. Res., 7:529.

The percentage of culls was higher, however, in the seven sprayed plots than on the five, consequently the marketable yield from these two were about the same.

The yields on the various plots were as follows:

Average yield in bushels per acre for five year period of Rural New Yorker sprayed with Bordeaux Mixture.

Number of Applications	Total yields per acre Bushels	Marketable yield per acre Bushels	Culls per acre Bushels	Per cent culls	Bushels per acre increase from spraying	Per cent of gain over marketable yield due to spraying
3	130.2	114.3	15.9	12.2	10.4	10.0
5	139.1	120.9	18.2	13.1	17.0	16.3
7	142.1	121.5	20.6	14.5	17.6	16.9
Cheek	120.9	103.9	17.0	14.1		

It will be noted that in going above five applications we reach a diminishing return and the net gain is not sufficient to justify the two additional applications. On the other hand, three applications were not sufficient to justify the expense. Expressed in terms of percentage the total gain in yield in the Iowa experiments from five applications averaged sixteen percent, which seems to correspond favorably with the percent gain in the Geneva experiment in the years in which late blight and early blight were not present.

The labor cost for one if not two of the applications should be cancelled as the bordeaux can be added to the insecticide which must be applied in any case. The bordeaux also aids in the control of flea beetles.

The Iowa experiments relate wholly to late potatoes, the Rural New Yorker being the variety used.

On the average, tip burn is much more severe on early potatoes than on late. It is, therefore, possible that the results from bordeaux applications on early sorts will give a wider difference in favor of the spray pump. This phase of the question we hope to have more complete information on later.

The spray pump has revolutionized the fruit industry as an agency for the control of fungous diseases. In the case of the potato crop in the corn belt the basic idea is that of using bordeaux for a physiological response, primarily. In this respect the proposition is distinctly novel, and if successful, will open up a new field of activity for bordeaux which may prove far-reaching.

EXPERIMENTS IN SELECTING TOMATOES FOR WILT RESISTANCE.

By C. E. DURST, *University of Illinois, Urbana, Illinois.*

Fusarium lycopersici, which is the cause of a serious wilt of tomatoes in practically every important trucking section of the South, has within recent years become a serious obstacle to tomato growing in Southern Illinois. The Department of Horticulture of the University of Illinois, realizing the nature of the situation, began a series of investigations in 1913 which had for their object the reduction of damage from this disease.

A plat of ground was used which had become thoroughly infected with the organism. Sufficient fertilizers were used to make it possible to grow tomatoes continuously for the five years.

Attempts to control the disease by the use of common salt, limestone, and lime-sulphur residue resulted in failure.

In 1913, 48 varieties were tested. This number was increased to 61 in 1914 and to 65 in 1915. As a result of these tests, some varieties were discarded and the number was thus decreased to 43 varieties in 1916 and to 23 in 1917. These tests show that susceptibility to *Fusarium* differs considerably in different varieties. Unfortunately, those which exhibit the greatest resistance are for the most part lacking in important marketable requirements, being of too late maturity or having fruit of undesirable size, color or shape. Of the varieties tested, the Paragon, Perfection and New Century are probably the best of the red-fruited varieties for Southern Illinois conditions. The Earliest Detroit is the most promising of the red-fruited sorts tested.

As a result of selection, strains have been developed from varieties possessing desirable marketable characteristics which are capable of living through the season in thoroughly infected soil. Of a large number of selections made, those from the varieties New Century, Paragon and Imperial, are the most promising. In 1917, a selection from New Century bore 5.36 pounds of marketable fruit per plant before the close of the shipping season on September 10, while the stock obtained originally from the seedsman produced only 2.87 pounds per plant. One selection from Paragon produced 5.73 pounds and another 4.79 pounds per plant as compared with 3.5 pounds from the seedsman's stock. A selection from Imperial produced over two times as much fruit as the seedsman's stock from which it was developed. In these cases and in others the selected strains showed a much higher degree of resistance to the wilt than the stock originally obtained from the seedsman.

NOTE—This is only a digest of the address given at Pittsburgh. The complete address will be published by the University of Illinois at some future date.

COMMERCIAL EVAPORATION AND DEHYDRATION OF FRUITS AND VEGETABLES.

BY E. L. KIRKPATRICK, *Cornell University, Ithaca, N. Y.*

An increased production of perishable crops, along with a shortage of tin and glass containers, caused a nation-wide interest in drying, evaporating, and dehydrating the past season. While the United States Department of Agriculture, as well as many of the state experiment stations and state colleges, did a large amount of investigational and extension work in home drying as a means of preserving surplus garden produce, the problem of commercial evaporation and dehydration was given little or no consideration.

The terms dried, evaporated, dehydrated, and desiccated, as applied to fruits and vegetables, are more or less confusing to the public mind. While certain authorities class the four terms as synonymous, others designate dried or evaporated products as those from which the moisture has been removed with little or no regard to the degree of heat used, and dehydrated or desiccated products as those from which the moisture has been driven at a relatively low temperature, preferably 120 to 150 degrees F. In our discussion we need not confine ourselves strictly to any one of the four terms. With a uniformly-controlled temperature, under favorable conditions, it seems that certain dehydrated products might be turned out on the kiln evaporator. In order to limit the scope of our subject, dried products, which are usually considered as those preserved in the sun's rays or over the kitchen range, for home use, will not be discussed in this paper. Desiccated will be considered synonymous with dehydrated.

Evaporated fruits and vegetables, mainly fruits, are products of the kiln type of plant which has stood the practical test from the standpoint of economy of operation and of quality of certain products turned out. The kiln plant represents the third step in the apple evaporation industry in this country, having replaced the box and tower dryers when Germany refused our apples dried on zinc-coated trays. Kiln plants, while operated much more economically than most types of dryers or evaporators now in use, will not give satisfactory results with all kinds of produce. Potatoes, peaches, and sweet corn, for example, must be dried in thin layers if a first class product is to be secured. On the other hand, apples and berries, as well as many kinds of vegetables, can be dried in layers of from 3 to 8 inches and are handled satisfactorily on the kiln plant. During the past four years immense quantities of vegetables preserved on the kiln evaporators of Western New York and certain provinces of Southeastern Canada, have been used in England and France as an army ration. Should our commissary department see fit to use evaporated products or should the food situation become seriously acute in this country owing to a shortage of cars for moving green produce to the consumers, New York State has from 500 to 1000 plants, ranging in size from 2 to 10 kilns each, ready for operation at the first call. Moreover,

practically all of these plants are located within hauling distance of the muck and upland vegetable producing centers of the state.

In the kiln plant, produce ready for processing is spread on a slatted floor below which is located a hot air furnace with a coil of ten-inch pipe connecting it to the chimney. Heat radiating from the furnace and furnace pipes passes between the floor slats, through the produce, and out at the large roof ventilator above the center of the kiln, moisture laden. Temperature and time required for drying differ with the kind of produce the depth of loading, the number of times turned, the moisture content of the outside air, and the efficiency of the drying plant. At a temperature of 110 to 150 degrees F., 7 to 24 hours are required for drying apples, carrots, turnips or cabbage spread from 4 to 10 inches deep on the kiln floor. All the produce must be finished off in the curing rooms (sweated) by shoveling it over and back several times per week.

In modern dehydrating plants, produce on wire trays, spread in a single layer or to a depth of 1 to 3 inches, is dried in a steam heated chamber in approximately one-third the time required in an evaporator. While the chambers in many evaporators are fitted with power-driven fans or movable deflectors of some sort to keep the air in motion, several plants are giving satisfactory results without such arrangements. Several of the more modern outfits are equipped with temperature boosters or with automatic exhaustion regulators. As yet the dehydration system is in an early stage of development. The initial cost of the plants offered for sale, together with the cost of installation and the large amount of labor needed in loading and unloading the trays, favor a wider use of the kiln plants. However, the ability to secure a first-class product from practically any fruit or vegetable, without the use of sulphur or other bleaching agent, points to a successful future for the dehydrator.

Whether it be evaporation or dehydration, let us define the system as the removal of moisture from produce, to such a degree that the produce will keep under ordinary conditions, without deterioration. Provided the moisture is properly removed to a certain desired stage, that is, removed with sufficient heat to accomplish the purpose, only, the cell structure of the product is left intact or undestroyed. The dehydrated product resumes its natural shape and, with slight allowances, its color and quality when placed in water for a certain length of time. This necessitates that the product be not dried to a crisp state or to a point of caramelization, but that from 6 to 25 per cent of its water content be retained.

Practically no undesirable change should result during the dehydration process. According to certain scientists, the right degree of heat should favor changes similar to those which occur during the natural ripening of the fruits or vegetables and should tend to soften the crude, fibrous parts. Whether or not such is the case in actual practice remains to be seen.

Certain principles must be strictly adhered to if evaporated or dehydrated products are to be a commercial success. It should be borne in mind that nothing can be added to the product during the process. Experiences of a number of men in Western New York State during several

seasons past bear out this statement. Produce which goes into the plant as culls comes out as culls. Only first-class produce should be used. This does not mean that small-sized or off-shaped specimens cannot be used to advantage. Rather, the process of evaporation or dehydration should become a means of utilizing surplus products of good quality. Washing, peeling and blanching should be thorough. Some manufacturing firms argue that, in order to cut labor costs in operating their plants, vegetables need not be peeled. That depends, however, upon the use to which they are to be put. Although we class potatoes cooked in their jackets as having the higher food value, we like our potatoes for Sunday dinner without the peelings present. Authorities differ on the method as well as on the amount and the value of blanching. Scientists claim that blanching and partial cooking, previous to processing, fixes the chlorophyll and opens the pores, thus letting out moisture and acrid substances more readily. The result of our experience is a superior product without blanching, with the exception of sweet corn, potatoes and possibly one or two others.

Depth of loading the trays, humidity of the drying chamber and of the outside air, temperature and time used in drying, as well as the final moisture content of the product, must be studied and standardized in so far as possible. Bleaching agents--sulphur dioxide and citric acid,--should be used as sparingly as possible until sufficient experimental work has been done to prove their use unharful.

All efforts must be directed towards getting a uniform product throughout. Since dehydrated foods can be easily shipped the consumer is likely to receive his lot from any section of the country where green produce can be grown easily. Given a good quality product with sufficient information regarding its use once, he will buy again. Given a poor product at any time, he will cease to buy altogether.

Neat and attractive containers must be used in getting the product before the housewife and the consumer. Dehydrated food is not a bulk food. It must be handled in small quantities. On each package should appear directions for restoring the product to its original shape, along with several good recipes for its use.

Dehydrated foods may never gain the popularity of canned foods. They are not emergency foods, except in rare cases. The housewife must plan one day for her meal from dehydrated foods for the next. Yet we have no reason to believe that the interest shown in them during the past season will subside with the present War for Peace. Nor do we know that the war will cease before dehydrated foods have become articles in the average family diet.

During any period of congestion in freight traffic, as we have at present, it seems unwise to ask that 6 or 8 tons of water be moved with every ton of real food; for, we must bear in mind, the water content of practically all fruits and vegetables ranges between 75 and 95 per cent. Fresh tomatoes are 94.4 per cent water, celery 94 per cent, onions 93 per cent, spinach 92 per cent, carrots 88 per cent, squash 86 per cent, apples 84.6 per cent, sweet corn 81 per cent, and potatoes 78 per cent. When properly processed 100 pounds of fresh onions will produce approximately 8.5 pounds of the dehydrated product. One hundred pounds carrots will

produce 10 pounds, 100 pounds squash, 5 pounds; 100 pounds cabbage, 8 pounds; 100 pounds celery, 7 pounds; 100 pounds spinach, 7.5 pounds; 100 pounds apples, 15 pounds, and 100 pounds raspberries, 15.5 pounds.

A means then of reducing the water content of produce, against adding water and in some cases sugar, as is added in canning, thereby reducing the original bulk of the produce to $\frac{1}{2}$ or $\frac{1}{3}$ cutting the cost of transportation by half, and changing a perishable food to a non-perishable, should be a matter of great concern to horticultural scientists, as well as to the average producer and consumer. In handling dehydrated products the public will not be confronted with the serious problem of storing bulky or perishable crops. The use of parchment-lined or paraffined pasteboard containers will be found a ready means of holding perishable crops over until needed by the public, thus avoiding price-cutting due to gluts in the markets. Two market gardeners, one in New Jersey and the other in Massachusetts, who have started operations along this line, are being eagerly and anxiously watched by manufacturers of dehydrating outfits, as well as by the consuming public.

While, as yet, the amount of vegetables preserved by evaporation is small, in comparison with the amount preserved by canning, quite the reverse is true in regard to fruits. According to the United States Census report for 1910, the total pack of canned fruits for 1909 was slightly over 5,501,000 cases, while the pack of evaporated fruits was over 400,000,000 pounds. Reducing the bulk of raw fruits for each pack to the same basis, we find that approximately 164,000,000 pounds of raw produce were canned, while 2,400,000,000 were evaporated; the ratio of raw fruits used being .1 to 15. The figures for 1909 are in practically the same ratio as those of 1904 and of 1899. It is not unreasonable to predict that the system used so extensively in the preservation of certain kinds of fruits will be as widely used in the preservation of certain kinds of vegetables in the future.

What then shall be the attitude of the scientist or investigator toward this means of preservation and conservation of foods? Should he consider the process as nothing more than a war measure? Canned foods, which are so popular at the present time, came about through war measures of a century past. The science of canning was for many years considered a secret known only to the processor who sterilized the product. Shall we consider the dehydration system a secret similarly known only to promoters anxious to sell high priced outfits or patent rights, or shall we undertake an immediate investigational and experimental study of the process in order that producers and consumers may know of its actual value?

THURSDAY, DECEMBER 27, 2 P. M.

CORRELATIONS BETWEEN FRUIT AND FOLIAGE IN STRAW- BERRIES.

By B. S. PICKETT, *University of Illinois, Urbana, Illinois.*

The correlation and association of characters in plants are matters of recognized importance from several standpoints; therefore, it is not necessary to devote time to an explanation of their meaning or to a dissertation on their significance. It is the speaker's aim in this paper to present certain facts determined by comparing numerous measurements of the fruit and foliage of 900 seedling strawberry plants, and mindful of the sentiments expressed by this Society at its session in 1916, and of an intimation more recently expressed by the chairman of the program committee, to describe in some detail the processes and methods by which the results were arrived at.

Although observations were made on several characters of the fruit and foliage of strawberries, the results presented here will show the relation between (1) the average weight of berries and the average area of the leaflets, (2) the total production of fruit and the total area of the foliage, (3) the number of leaves and the number of berries.

If scientific method be analyzed, it will be found to comprise (1) accurate observation of facts, (2) careful notation of the observations (3) arrangement of the notations, (4) conclusions. Observation and notation go hand in hand in this experiment and therefore, are presented together.

The experiments were performed several years ago in the gardens of the New Hampshire Agricultural Experiment Station at Durham, New Hampshire. The seedlings were crosses involving seventeen varieties, Almo, Brandywine, Cardinal, Clyde, Ernie, Fairfield, General De Wit, Glen Mary, Hummer, Marshall, North Shore, Pan American, Parson Beauty, Sample, Senator Dunlap, Uncle Jim, and Wild Wonder; thus sufficient variation for the study seemed reasonably assured. The seeds were germinated in six-inch pots in the greenhouse, pricked into two-inch pots as soon as large enough to handle, and transplanted to the garden in the spring of 1908. They were planted in a well-drained sandy soil rather lacking in humus but well fertilized for several years with commercial fertilizer supplemented with light dressings of stable manure. The plants were set in rows 30 inches apart with 18-inch intervals between the plants. The hill system of culture was rigorously followed throughout the season and a uniformly successful stand of plants was obtained.

Thus far the work presented no difficulties beyond the continued vigilance necessary to remove the runners as fast as they appeared. But with the harvesting of the fruit came a serious problem in organization. Records were made of the weight, volume, color, form, and seed characteristics of each berry. As the plants were of remarkable size and vigor, many producing upwards of 100 berries and a few upwards of 200, the recording force had to be quite large, and as only one skilled assistant was

available, the recorders had to be trained, record forms devised, and abbreviations invented in order to insure accurate and rapid work.

The berries were all harvested by one man. Each plant was marked with a 12-inch numbered label. The fruit was picked into paper sacks numbered to correspond with the plant, and carried to the recording room. The recorders worked in pairs, one person making the observation and the assistant noting the result on the blank provided.

The method of weighing and determining the volume was novel and expeditious. The apparatus used was a "jolly balance," a weighing instrument familiar to all students of Physics. Essentially it consisted of a coiled spring, a graduated rule, and a mirror. The spring was very small piano wire, loosely coiled so as to respond delicately to the light weight of a berry. It was adjusted to read 1 gram per centimeter on the scale, which in this case was a meter stick graduated to millimeters. The berries were placed in a tea basket suspended from the lower end of the spring, the basket counterbalanced simply by moving the scale so that the zero point would be opposite the pointer. The weight was read where the pointer in the mirror appeared to touch or line with the pointer on the scale itself, thus insuring accurate reading of the weight. To obtain the volume an inverted scale, based on the relation between specific gravity and buoyancy, was placed on the measuring stick, the volume being read directly when a glass of water was slowly raised so as to submerge the basket and the berry. It was necessary to perform this operation deliberately to permit the escape of the air through the meshes of the basket and from beneath the lobes of the calyx. Two or three days were devoted to the perfecting of the weighing apparatus before the harvesting operations began and refinements of the system were developed as the work progressed.

Berry descriptions were facilitated and standardized by several devices. Colors were described as scarlet, crimson, and maroon, green tips being noted when they occurred. Fresh sample berries of these colors were placed before the describers each morning for reference and comparison. Forms were described as round, conic, wedge-shaped, cock-scomb, and irregular, and were illustrated by sample berries. The seeds were described as to color and location, scarlet, yellow, and maroon for colors and superficial or imbedded for location. Intermediate characters were described by combining the terms, thus, crimson to maroon, round to conic, etc., but descriptions of this kind were not encouraged.

Immediately after the close of the picking season, the living leaves on each plant were cut close to the crown, tied in bundles, labelled, and pickled in formalin solution. During the following winter 20 leaves chosen at random from each bundle were measured with a planimeter. The wet leaf, soft and flexible, was spread on a blotter, covered with a sheet of glass to hold it flat, and the perimeter of each leaflet traced through the glass.

Having observed and noted the facts we come to the third step in the formula, arrangement of the notations. This involved first a summary of the data. So far as the mathematical observations were concerned, this process, though tedious, involved no great difficulties. The additions

were made on an adding machine and were checked by comparison of the machine slips with those of the original record sheets. (The other records, I regret to say, still remain unsummarized.) All the mathematical data were then brought together in tabular form on a special sheet.

From the summary thus prepared were constructed correlation tables which gave a mathematical expression for the relations which we were studying. Most of the members present are familiar with the construction and theory of the correlation table.

The results obtained in this manner showed that the correlation between the number of leaves and the number of berries was $.4792 \pm 0.002165$; that the correlation between the average area of the leaflets and the average weight of the fruit was $.28904 \pm 0.00456$; and the correlation between the total area of the foliage and the total weight of the fruit was $.7503 \pm 0.001212$.

From the standpoint of pure science the results just stated are conclusions, but from the standpoint of the horticulturist they may be regarded merely as a convenient summary or assembly of the facts, a working formula, if you please. It remains, then, to weigh and judge these assembled facts, so that their application may be made to plant breeding and general culture, this making the final step in the scientific method, the conclusion.

No one individual can foresee all the applications of any general truth. Those interested in correlation studies will interpret the data in the light of their own research and experience. The speaker will undertake to point out, therefore, only three typical conclusions.

Since the correlation between the total amount of foliage and the total production of fruit was very large, i. e., 75 per cent, and since the other correlations were not inconsiderable, the experimenter was immediately tempted to regard the result as of great value to the strawberry breeder in the selection of seedlings. An examination of the summary or of the correlation tables showed, however, that many promising seedlings would be discarded if the foliage characteristics alone were used as a criterion of the performance of the plants. The question then arose, "Will the advantage of reducing the number of seedlings by selection based on the correlations discovered compensate for the risk of losing valuable seedlings?" And the first of the three conclusions was this: "the value of knowing these correlations, as a means of facilitating selection in strawberries, is not great, for the reason that this species is so easily propagated and so quickly brought to maturity that complete observations may be made so easily and cheaply as to render it unnecessary to risk the loss of valuable plants by selections made in the seedling stage."

Conclusion number 2 is more satisfactory from the standpoint of its application in plant breeding, viz.: — that possibly, not probably, similar correlations exist in fruits which are slow to mature, and that the principle that has proven true in strawberries may be applied in tree fruit selection; at the least it encourages similar investigations of correlations between fruit and foliage in tree and bush fruits.

The third conclusion is the most interesting of all to the writer—the significance of these correlations to the general culture of fruits. For the relationships observed indicate that, so far as strawberries are concerned, abundance of foliage and high production go hand in hand. Therefore, not only variety selection but all that good culture implies should be effective in increasing yield. Again, this principle possibly, even probably, applies to other fruits as well, and at the least, challenges the experimenter to investigate the subject still further.

AN INVESTIGATION OF THE INTERRELATION OF STOCK AND SCION IN APPLES.

By J. K. SHAW, *Massachusetts Agricultural Experiment Station,
Amherst, Mass.*

To what extent the seedling root system of our grafted orchard trees influence the growth and fruitfulness of the individual trees is one of the many unsolved problems of pomology. The question is often asked and we have on record numerous observations, but so far as we are aware no thorough, long-continued investigation of the problem had until recently been undertaken.

All through New England, but especially in the southern part, there are many top grafted trees. Many of them have been grafted by the insertion of a single scion in the trunk of the tree. In nearly every case the point of union is very evident. Often the trunk diameter is greater above than below the union. Occasionally the reverse is true, but such cases are much less frequent. Most top worked trees are Baldwins and there is great variation in the size and vigor of the top and in the fruit, some of which may be reasonably ascribed to influence of the stock.

The effect of various dwarfing stock furnishes us most of our knowledge on this problem and doubtless the Doucin and Paradise stocks used for this purpose are merely varieties similar in their effects to Northern Spy and Oldenburg.

Many of the observations on the interrelation of stock and scion are based on trees in which the bearing top is one variety, the trunk and perhaps a part of the root system is another variety, and a part or the whole of root systems are unnamed seedlings. In the investigations at the Massachusetts Experiment Station now under consideration, each individual tree is root, trunk and top of a single variety, or in most cases, the root is one known and named variety, and the trunk and branches are another variety.

It being evident that a thorough-going investigation of this problem was an undertaking involving many years of painstaking study and a considerable expenditure of funds, we tried first of all to lay a solid foundation of well-considered plans and adequate preparations. The project as outlined provides for a period of twenty years. While it is doubtful if it is completed in that time, it will probably need to be redirected at the end of that period.

The first thing was a survey of the literature supplemented by information obtained by correspondence with other investigators. Special inquiries were directed to nurserymen both by correspondence and by personal interviews to obtain all available information bearing on the technical problems which would be involved. This survey concerned not only the problem of the interrelations of stock and scion, but a minute consideration of varieties that might be used, of methods of orchard and nursery management, of the best and most recent ideas of plot size and arrangement, and many other problems as well. After due consideration of these many factors a project was written which was subjected to the criticism of other members of the college and station staff, of the director and finally to personal conferences with the officials of the Office of Experiment Stations with a view to its approval as an Adams project and in this way assuring, as far as possible, continued financial support.

Finally a project covering for a period of twenty years the purpose, the essentials of procedure, and the financial requirements, was evolved which has now been followed for five years without material deviations and which it is felt can be adhered to for the remaining fifteen years.

We have dwelt thus briefly on this phase of the problem not under the impression that we were saying anything new, but because the importance of thorough and adequate preliminary consideration of a piece of investigation cannot be too strongly emphasized, especially in the field of pomology where long-time investigations are especially called for. Too often is experimental work halted by obstacles or rendered futile because of ill-considered plans instead of being successful and profitable through careful and continued preliminary consideration.

The investigation was started in 1912. Five years have sufficed only to get the work well established. It was the plan to confine the investigation to a relatively limited number of varieties. Six were chosen as scion or top varieties, and fifteen as stock or root varieties. Most of these were well-known varieties of commercial importance. They were selected with a view to including those differing in vigor of growth, season, color, acidity, bearing age and habit of growth. Incidentally many other differing characters were included. The scion varieties were Baldwin, McIntosh, Red Astrachan, Tolman, Wagener and Yellow Transparent. Of the fifteen root varieties selected, Tolman and Transcendent Crab had to be eliminated, the former because it could not be induced to root in sufficient numbers, and the latter because of a combination of circumstances through which only a few trees became available. Four other root varieties rooted in only small numbers so that they are included in a less number of trees. These are Baldwin, Hubbardston, Jewett and Rhode Island Greening. There were thus nine varieties used to the full numbers, Ben Davis, Bough, Northern Spy, Oldenburg, Red Astrachan, Wagener, Wealthy, Yellow Transparent and English Paradise. All of the six scion varieties growing on their own roots were included. Baldwin, Red Astrachan, Wagener and Yellow Transparent being included in the lists of both scion and root varieties, we have them worked on stocks of the same variety, so as to catch any mechanical effect of the union if such effect exists.

The major block of the orchard includes 858 trees. The first sixteen rows of thirty trees each are alternately Red Astrachan and McIntosh, and Yellow Transparent and Baldwin. Each row is made up of ten plots of three trees each on the ten major root varieties named, including the own rooted trees. In each of the four rows of the scion varieties these plots are arranged in a different order. Thus we have of each combination four plots of three trees each well scattered over the orchard. This is, of course, to give a check on any soil variations. This bids fair to be a most valuable feature of the experiment and the only regret is that there could not be five or six plots of each combination instead of four.

The next four rows are Wagener and Tolman. These rows are 27 trees each of the same root varieties as the first sixteen rows omitting Wagener, and similarly arranged. Next we have six rows, one of each of the six scion varieties on the four-minor root varieties, two plots of three trees each of each combination.

In addition to this main body of trees we have 238 trees of eleven varieties on the root varieties already mentioned, together with eight additional ones. These various combinations are planted in plots of two to four trees each and each plot is in duplicate or triplicate. The purposes of these odd combinations is to serve as feelers for any combinations that may reveal special or striking results. Then we have seventeen additional varieties growing on their own roots in plots of three each.

In order to serve as a check on this orchard we started last spring a second orchard in another part of the state on a different soil. The varieties are Baldwin, McIntosh, Wagener and Wealthy, on roots of the same varieties used in the main orchard, also a number of ordinary nursery trees on seedling roots. This orchard has now 267 trees and it is hoped to make substantial additions to it in the near future. The orchard is to be carried on as a demonstration orchard in co-operation with the Extension Service of the College. In it we hope to demonstrate good orchard methods in general and that it may serve to demonstrate the factor of root influence should it prove to have practical significance.

The orchard plantings in this investigation thus include 1,414 trees so arranged and planted that we hope they may yield a substantial contribution toward the solution of the many problems involved in the interrelation of stock and scion.

The experiment orchard soil is a fine sandy loam. It was considerably exhausted of fertility when assigned for this investigation. Two crops of soy beans were plowed in before planting the trees and since then the orchard has been managed on the cultivation-cover plan except in 1916, when a crop of field corn was grown. No fertilizer has been applied directly to the trees and it is felt that so long as a good cover crop can be grown either with or without fertilizer, a satisfactory tree growth can be maintained without the danger of increasing individual differences among the trees which might follow direct application of fertilizers.

The system of pruning followed calls for moderate dormant pruning. Attention has been given to securing a well-formed head with as little pruning as possible. Little or no heading back has been practised. Prunings from each tree will be weighed and the caliper at a fixed point indicated by a slender brass nail driven into the trunk, taken annually. As soon as they begin to bear, the yield from each tree will of course be recorded, and this in itself will be a valuable record.

The first part of our problem is to determine what effects follow the combinations under investigation. This is the experimental phase of the problem which must precede the research phase which aims to lay down principles and formulate laws by which we may know before hand what results will follow new and untried combinations. This end must be achieved if this long and painstaking investigation is warranted.

At the outset of the experiment in 1912 we faced the question of how to get trees on known roots. This must obviously be by inducing wood tissue to produce roots. The methods that suggested themselves were cuttings, and layers of various sorts, and the long-scion short-root graft where a short piece of seedling root serves to sustain a scion or cutting until it can send out roots. Many methods of growing cuttings have been tried, using many varieties, but all so far have proved failures; not one has succeeded, yet there seems to be reason to believe that it may be done. The cuttings of some varieties callus beautifully, but there they stop, the desired roots are not forthcoming.

Air layering has been tried to a limited extent without success. Mound layering does not seem as successful as might be expected, yet more trials might yield better results. It is hoped to try this method more extensively in the future.

An attempt to grow root cuttings from beneath nursery trees gave encouraging results and we tried to attack the main problem from another angle. We secured root cuttings from beneath bearing trees which showed marked differences that might possibly be due to different seedling roots and attempted to grow them, intending to bud the trees to the original variety and see if the same differences appeared. This resulted in a failure, as repeated trials failed to secure more than a few scattered successes among the attempts to start these root cuttings. The reason assigned is that these were from beneath mature trees and thus of relatively old wood, instead of young nursery trees.

We have secured in connection with this investigation over 3,000 trees on roots of known varieties. Practically all of these have been secured by the long-scion short-root method. A whip root graft is made in the ordinary manner, the scion being seven or eight inches long and the root about three inches. This is planted by means of a special dibber so that all but one or two buds are under ground. These are cared for by ordinary nursery methods for two years. The first year's growth is cut back to the ground, for this gives at the end of the second year a straight, strong whip much more desirable than the weak, straggling two-year-old tree that results when cutting back is not practiced.

By this method some varieties will root from the scion in practi-

cally every case. Among more than a hundred varieties tested none has been found that absolutely refuses to root, but several yield less than 5 per cent of rooted trees.

Within the variety we have been unable to make any progress whatever in discovering why one tree roots and another does not. Small, weak trees seem as likely to root as strong, vigorous ones. There is no obvious relation to soil conditions. There is often much variation between different lots of one variety, but why is unknown. Whether there is a difference from season to season is uncertain.

There seems to be some reason to think that the varieties which root readily are those with comparatively soft wood and those that root with difficulty have relatively hard wood, but the correlation does not seem perfect. No careful tests of hardness have been made, however. In some cases, at least, varieties that root easily have a greater number of cell layers in the cambium, and this again may perhaps be correlated with softness of wood.

After growing two years the trees are dug and from those showing roots from the scion the seedling root is cut away and the tree replanted. Even when the roots are few and weak the tree usually lives, though it may make a weak growth the first year. In order to avoid the checks resulting from cutting away the seedling root, the scheme of using a piece of root cut from trees already established on their own roots has been tried. Some two hundred grafts of four or five different varieties were made, but only a scattered few started, while adjoining rows grafted in the ordinary way gave 80 per cent stand or better. The only reason that can be assigned is that the roots were doubtless two-year-old wood, while seedling roots are always one-year-old wood. This result is similar to that from attempting to induce root cuttings from old trees to grow.

In connection with this investigation a considerable number of experiments bearing on various phases of propagation have been made. It would be tedious and out of place to discuss them here, but they are interesting in showing the fallacy of many notions that prevail. In fact, it is doubtful if there is any branch of agriculture in which there is so much of empiricism and mere whim as in the nursery business. This is a virgin field for scientific horticultural investigation.

After the seedling root has been cut off and the tree replanted it is budded to the desired variety and cut back the next spring in the usual manner, and we have the tree established on known roots. As a matter of fact, most of the trees already secured have been budded the first summer after setting the graft, and when the tree is dug for inspection and removal of the seedling root we have the bud variety on a known root. In this way we save time by securing the tree on known roots in two years, provided it roots from the scion. There are several objections to this method and we now regard it as more satisfactory to get the tree on known roots before budding unless one is particularly anxious to save time.

The results in detail of our experiments in propagating trees on known roots will be published as soon as they are completed.

The oldest trees in the main orchard have now had three seasons' growth in the orchard. It is too soon to draw conclusions as to the in-

fluence of the different roots upon any given variety, though we think that differences are beginning to appear. Oldenburg has so far proved an inferior root variety, many of the trees making a very poor growth or failing altogether. McIntosh on Transcendent Crab makes a strong growth, while Red Astrachan on the same variety is dwarfed in a remarkable fashion. McIntosh and Stayman Winesap on their own roots make a remarkably strong growth. Other cases only a little less striking might be mentioned did time permit.

The trees have had the least pruning possible, and yet secure well-formed trees. As one looks along the rows it is possible to detect in many rows differences in form of the top, the three trees in one plot being much alike and differing from the trees of the adjacent plots. These differences are slight and it is impossible to say whether they will disappear or become more marked as time passes.

There also seem to be differences in size of the trees on different roots. However, influences arising from soil and other causes are so potent as to obscure these differences to a considerable degree.

Among the 858 trees of the first planting in 1915, thirty blossomed in the spring of 1917 and several produced fruit. All were among the McIntosh, Yellow Transparent and Wagener trees, and nearly all were on English Paradise or Northern Spy roots. The latter variety seems to be in many respects a dwarfing stock especially for Yellow Transparent. This observation is in harmony with what we have been informed is the experience in South Africa, where Northern Spy stocks are extensively used on account of their resistance to injury from the woolly aphid.

If one were to attempt a summary of the influences affecting the growth of the trees, omitting the factors of soil and age of the trees, as they appear at the present writing, perhaps they would be as follows:

1. The vigor of the scion variety.
2. The rooting ability of the stock variety.
3. The vigor of the stock variety.
4. In certain cases the compatibility of the stock and scion.

Probably the second of these is temporary and will become relatively unimportant in time. Still the ability to produce roots from the scion readily may mean the power also to produce a large and vigorous root system which would presumably help to produce a large and vigorous top. Generally speaking, a given variety on roots of a weak growing sort seems to be less vigorous than on roots of a strong growing variety. Whether the vigorous top will in time impart vigor to the root system and to what degree remains to be seen.

It seems that among the varieties used there are some that are relatively incompatible, that make a poor union inhibiting the growth of the top. Many such cases are to be seen among the old-top-worked trees in New England, though probably many extreme cases have perished. This is a problem in itself which will call for special consideration as time passes.

We are nearly through the stages of preparations and establishment of this investigation. The next fifteen years should witness the accumulation of a great deal of valuable data bearing on the interrelation of stock and scion in apples and upon many related and subsidiary problems.

NOTES ON THE NOMENCLATURE AND CLASSIFICATION OF CURRANT VARIETIES.

By PAUL THAYER, *Ohio State Experiment Station, Wooster, Ohio.*

I shall make no apology for bringing such an old-fashioned subject as nomenclature before this up-to-date body, for I feel that all of you realize its importance, forming as it does, one of the foundation stones on which all, or nearly all, horticultural work is based. Correct nomenclature as a pre-requisite to variety testing is self-evident and yet, when one finds such glaring errors as the Captain Ede described as a white peach, one feels the force of Davy Crockett's admonition: "Be sure you're right, then go ahead."

Variety tests in which there is a shadow of doubt as to the identity of the varieties reported upon are not simply valueless, they are injurious, in that they lead astray the feet of those who follow after. Much of the same may be said concerning the increasingly important subject of plant breeding. Correct nomenclature will not in any way affect the value of the new varieties produced, but when we begin to deduce laws of inheritance, to study the prepotency of different varieties, we will lead those who follow after us astray if we are not certain as to the correct names of the parent varieties. It would not be at all unlikely if the results of breeding work showed more or less seeming contradiction resulting from faulty nomenclature. Similarly, though to perhaps a less degree, the selection of varieties affects the results in experiments in culture, fertilization, pruning, thinning, etc., and a doubt as to the correctness of the variety names impairs the value of the experiment.

Thus, while nomenclature of itself may seem elementary to many workers, it is not simply elementary, but fundamental. The horticultural world owes much to Professors Beach and Hedrick and their associates at Geneva for the splendid works on the fruits of New York. There yet remains another work to be done. Just as on the desk of the teacher of English, beside the dictionary, is a copy of Crabbe's English synonyms, so some one, sometime, will prepare for the horticulturist a companion book for these fruit monographs, a book of horticultural synonyms, pointing out to the horticulturist who is familiar with the groups and families of each fruit the particular characters which distinguish the different members of the group, the difference between the McIntosh and Louise apples, the Engles, New Prolific and Kalamazoo peaches, and the Concord, Cottage, Worden and Moore Early grapes. Such a work, calling attention to the points of difference between varieties liable to be confused, should prove invaluable to the man whose work compels him to identify varieties.

The Ohio Experiment Station did not with deliberate premeditation attempt the straightening out of the tangles in currant nomenclature; on the other hand, our taking up of the study was, in a way, accidental. In 1912 a variety plantation of currants was set with the expectation of making a report on their comparative behavior. When these plants fruited, red varieties bore white fruit, white varieties bore red fruit, the same variety from different nurserymen differed widely, while different varieties from the same nurserymen proved identical. Fully one-third of the lots of plants contained one or more plants untrue or were entirely wrong. What started out to be a variety test turned out to be more nearly a test of nurserymen. An examination of horticultural literature in an effort to check up on the nomenclature revealed a lack of any exact technical descriptions. Statements such as "bushes large, erect, vigorous," "clusters long, well filled," "berries larger than Red Dutch with fewer seeds," are too indefinite to use in the identification of varieties.

Two avenues lay open to us, to drop the project and let what effort and study had already been spent go for naught, or else, through a thorough study of all the literature and living plants available, attempt to straighten out the nomenclature and standardize the descriptions of currant varieties. We chose the latter and secured more plants for study until now we have growing over 300 lots of currants, representing 96 varieties. These include all the varieties listed by American Nurserymen as well as a number from England and France. In many cases the variety is duplicated from different nurseries, in one case a variety having been secured from nine different sources, and I doubt very much if we have the true variety at that. A review of horticultural literature was undertaken with the aim of securing historical data and more authentic and characteristic descriptions. The work is not completed, in fact, the task looks bigger as we go on, but from the work already done we have drawn some conclusions that may be of interest:

1. The stocks of currants at present in the hands of nurserymen are very badly mixed.

2. This confusion is not new but has been complained of from time to time by horticultural writers.

3. With nursery stocks badly mixed it would not be strange if private collections have contained many varieties incorrectly named. This being granted, we should not be surprised to find (as we do) discrepancies and disagreements between different writers concerning the same variety. This doubt as to the possession of plants true to name casts suspicion upon practically all that has been written on varietal characteristics.

4. Until about 1850 nursery catalogs in their descriptions paid almost no attention to the plant, but confined their descriptions to size, color and flavor of the fruit. Since that date the references in catalogs to plant characteristics have been in very general terms.

5. The size of fruit, both in bunch and berry, is variable in the extreme. It varies according to position on the bush, age of plant, vigor of plant, soil fertility, crop, season, etc., etc. A statement such as: "Fruit about the size of" or "Fruit larger than," which usually occupies an

important place in any description, is too indefinite to be of any value in identification.

6. In a few cases there is some outstanding characteristic which enables us to feel certain that the variety with which we are dealing is the one which originated under that name. The spreading habit of the White Grape is mentioned by nearly every writer on that variety, while the introductory description of the Bar le Duc makes mention of the wavy-edged foliage which is so characteristic as to make identification certain.

7. In at least two cases the early descriptions do not tally with the fruit as now grown, and we have every reason to suppose that a substitution has occurred and the true variety has disappeared. The North Star currant originated about 1886. Eight years later, in *American Gardening* for 1893-4, is to be found a rather sharp discussion of the merits of this variety, some writers claiming it to meet the introducers' descriptions, while others claimed it to be little, if any, superior to Red Dutch. All the North Star plants we have fruited at Wooster have proven to be Red Dutch, and it seems reasonable to believe that the genuine North Star is practically out of cultivation today. The other case is that of the Cherry. All early descriptions speak of size of berry, shortness of cluster and lack of productiveness as characteristic of this variety. The Versaillaise, which M. Bertin raised from seed of the Cherry, overcame the defects of size of cluster and unproductiveness, and so far as they have fruited our plants of Cherry and Versaillaise show little or no difference. I am of the opinion that the genuine Cherry currant is no longer offered for sale, at least by American nurserymen.

8. There is a number of varieties of recent introduction which can be traced back to the originators with sufficient readiness to make us certain that they are true to name.

9. In some cases the fact that the variety as received from different nurserymen is uniformly identical and agrees with the meager published descriptions makes it probable that the variety is correctly named.

10. In numerous cases there is nothing of sufficient definiteness in past descriptions to warrant us in saying that the variety as at present known is the same as that originating under that name.

CLASSIFICATION.

Scant attention has been paid to any grouping or classification of currants. The red and white varieties are generally supposed to have come from a single source and are usually assigned to *Ribes rubrum* or *Ribes vulgare*, some writers classifying them according to color. From our studies it would seem that there are three or more distinct types or groups of currants, probably representing at least three different sources from which our varieties came. We have not worked out a complete key for identification of varieties, but we have, as a result of our studies, recognized certain varieties as having common characteristics and have accordingly grouped them together. This may be the beginning of a complete key, but at present serves simply to break the varieties into a number of groups or families.

Before taking up the differentiating characteristics it might be well to enumerate the characters which afforded little or nothing of value in the way of classification.

1. *Winter Appearance*—There is little in the dormant appearance of the currant bush to be of aid in identification. This lack has probably contributed to the mixing of varieties in the nursery referred to above. There are slight differences of buds and branches which are not to be ignored, and yet which seem too inconsequential to base groupings upon.

The habit of growth gives some clue, but it is a characteristic observable at any time of year and is not sufficiently marked for classification purposes.

2. *Inflorescence*—There is considerable variation in shape and color of the flowers, but as this is associated with equally striking difference in foliage and fruit the floral characters are not indispensable to a varietal study, though their value should not be ignored.

There remains the fruit and foliage upon which to base our groupings. The characters of these are observable over a reasonably long period and synchronously. While the botanist, who is accustomed to work with herbarium specimens is fitted to deal with a classification embracing features observable at different seasons of the year, there is, to me, a distinct advantage to the horticulturist in a classification simple enough to be used without pressed specimens or a series of repeated observations.

3. *Size of Fruit*—Since this is such a variable factor it is not adapted to use in any scheme of classification.

4. *Color of Fruit*—This would seem to be the most obvious character to use and yet it is not the best, especially for the primary divisions. In the first place, color is what might be termed accidental. Horticultural literature contains numerous instances of red currant bushes bearing white currants and even of clusters bearing berries of both colors on the same stem, or parti-colored berries in clusters of otherwise red fruit. Also there is less difference in every characteristic, save color of fruit, between the Red Dutch and White Dutch than between any two red currants or any two white currants.

5. *Foliage*—A study of the foliage shows many differences in form and structure of the leaf, lobing, position, color, pubescence, etc. These differences seem more or less correlated with fruit and flower differences and it is upon these foliage characters that we have broken up the cultivated varieties into a number of groups. Further study may possibly change the grouping somewhat, and will probably carry the divisions down until the work approximates a key to the varieties.

The most striking variety in our test plots was the London Market. The foliage is a light yellowish green although without any suggestion of lack of vigor. The margin of the leaf is lighter colored, giving to it the appearance of being edged with white. As the season advances the variety becomes less conspicuous, but even up to harvesting time the foliage is markedly lighter than that of any other variety.

In sharp contrast with the London Market is a group of currants characterized by deep black-green foliage, heavy, stiff stalks and

late fruit. In this group the new shoots are bright red during May and June. The varieties in the group are Rivers Late Red, Franco German, Prince Albert and Long Bunch Holland, how many of these being synonyms I cannot say. They probably represent a different species from the other varieties, but that remains to be determined. This belief is sustained by some recent unpublished work in disease susceptibility by the United States forest pathologists.

The remaining varieties of currants I have divided into two groups by a characteristic hard to describe and yet, I believe, reasonably easy to observe, namely, the thickness and texture of the foliage. About 1840 M. Adrien Seneclauze, a distinguished French horticulturist, received from Italy, among a lot of currants, one which he called, from its size, the Cherry. Some day some one will trace this currant back to its origin and will find, I believe, that M. Seneclauze, in introducing the Cherry, introduced a new race of currants since all its known descendants, as well as many probable descendants, are conspicuous for thick, coarsely veined leaves in marked contrast to the thinner, finer-veined leaves of varieties like Red and White Dutch, Knights and Victoria, which we know have no cherry blood in them. Since writing the above I have been reading Alfred Rehder's classification of Ribes in Bailey's Encyclopedia and have also seen the Monographie des Groseilliers by Janczewski. Both these gentlemen divide the currants into two major classes and the latter makes comments regarding the origin and influence of the Cherry currant not far different from those above.

The remainder of the classification follows this paragraph, and I think needs no explanation. As I said in the beginning, this is not a final report, but simply a record of observations and impressions as the work has progressed.

Provisional Classification of Currant Varieties.

- A. Foliage very light green, margin of leaf lighter colored giving the leaf the appearance of a narrow edging of white. Leaves late to fall. Fruit red. *London Market*
- AA. Foliage very dark green, almost black, hanging on bushes until winter. Bush very vigorous, stiff. New shoots bright red during early summer; later, due to rapid growth, the epidermis cracks and peels from the new shoots. Fruit late, red (*Ribes sp?*)
- B. Leaves moderately wide, with a gloss to the upper surface. Fruit stems medium to short. Fruit medium red when ripe, late. . . *Franco-German*
- BB. Leaves rather narrow, smooth but not glossy. Fruit stems medium to long. Fruit light red, very late. *Rivers Late Red*
(*Prince Albert and Long Bunch Holland* probably also belong in this class)

AAA. Foliage variable in color, but neither as light as "A" nor as dark and rank as "AA." Fruit red or white.

B. Thick, coarsely veined leaves (*Ribes vulgare*, var. *macrocarpum*)

C. Fruit red *Cherry*
Fay
Filler
Comet
Perfection
Chautauqua
Red Giant
Crawford

C. Fruit white *White*
Imperial

BB. Leaves not markedly thick or coarse (*Ribes vulgare*)

C. Leaves folded or cupped

D. Fruit red *Red Dutch*
(N. Star)
Wilder
Red Grape
Knight Large
Red
Pomona

D. Fruit white *White Dutch*
White
Transparent
Bar le Duc

C. Leaves flat or nearly so

D. Leaves densely pubescent beneath

E. Fruit red *Victoria*
Dilnots
Scotch

EE. Fruit white .. *White Grape*

D. Pubescence on lower surface light

E. Fruit red *Red Cross*
Wilsons Long
Bunch

EE. Fruit white .. *White Versailles*

VARIATION IN APPLES AS DETERMINED BY THE POSITION OF THE FRUIT IN THE FRUIT CLUSTER.

By O. B. WHIPPLE, *Montana Experiment Station, Bozeman, Montana.*

In presenting this paper we claim to offer nothing more than a preliminary report of investigations in progress at this experiment station, dealing with this subject. This work was begun in 1915 and was really suggested by a prominent Montana fruit grower who insisted that the matter was of practical significance and that, in some varieties at least, it should be recognized in thinning. During the early spring of the same year the work of Hollister on "The Variability in the Length of Apple Stems," presented before this Society at its meeting in 1914, came to my notice. Untimely frosts have seriously interfered with our investigations and the results have been summarized from two seasons' work with three varieties only.

In outlining this work, we have accepted as the normal apple inflorescence a cluster of six flowers, this applying particularly to large fruited varieties. We realize that the number is not constant, but in clusters of less than six flowers close examination will often disclose an undeveloped or rudimentary bud or buds, and in clusters of more than six the extra ones are usually recognized as abnormal or growing out of regular order. For convenience, we have divided the flower cluster into three parts as follows: Blossoms 1, 2 and 3 (designated 1-3); blossoms 4 and 5 (designated 4-5), and blossom 6. Blossoms 1, 2 and 3 are those to the outside of the cluster and grow from the axils of fairly well-developed leaves (we are not sure that this description will hold for all varieties); blossoms 4 and 5 are borne in the axils of bracteal leaves, and blossom 6 terminates the inflorescence and is subtended by neither leaf nor bract.

Fruits are secured from a particular group of blossoms by removing before or during the blooming season, the flowers of the other two classes. In other words, in thinning for fruit from blossoms 1-3, those designated as 4-5 and 6 are removed before they have really set. After the fruit is set the clusters are thinned to one fruit. Approximately the same number of fruits from each group of flowers is taken from a tree. The data presented are for the varieties McIntosh, Wealthy and Arkansas (Black Twig); the first two probably being the most important commercial varieties of the state. The following explanation of measurements as taken in inches may be desirable:

Diameter is taken with calipers and represents the maximum cross section.

Longitudinal section is taken with calipers and is the maximum length of fruit from the base to the apex as commonly measured in descriptive work.

Total axis is from the tip of the stem to the base of the sepals.

McIntosh, 1915.

Fruit from blossoms.....	1-3	4-5	6
Number of fruits measured.....	36	29	20
Average diameter.....	2.79	2.72	2.66
Average longitudinal section.....	2.25	2.25	2.36
Average length of stem.....	.98	.86	.62

McIntosh, 1917.

Fruit from blossoms.....	1-3	4-5	6
Number of fruits measured.....	125	98	123
Average diameter.....	2.70	2.83	2.80
Average longitudinal section.....	2.20	2.38	2.50
Average length of stem.....	.94	.75	.64
Average total axis.....	2.30	2.28	2.36

Wealthy, 1917.

Fruit from blossoms.....	1-3	4-5	6
Number of fruits measured.....	125	116	115
Average diameter.....	2.60	2.63	2.77
Average longitudinal section.....	2.16	2.18	2.31
Average length of stem.....	1.06	1.05	.91
Average total axis.....	2.32	2.35	2.26

Arkansas, 1915.

Fruit from blossoms.....	1-3	4-5	6
Number of fruits measured.....	25	21	17
Average diameter.....	3.07	3.10	3.20
Average longitudinal section.....	2.36	2.52	2.67
Average length of stem.....	.91	.79	.48

In the three varieties studied, the length of the stem increased from the center of the inflorescence outward and the length of the fruit increased from the outside to the center. Total axis, as studied in 1917 in McIntosh and Wealthy, was quite constant.

McIntosh apples from blossom 6 had a decidedly open core, from blossoms 4-5 a core that would be described as partially open, and those from blossoms 1-3 a closed or slightly open core. In Wealthy there was a very slight tendency in the same direction.

In the case of McIntosh, the apples from blossom 6 were decidedly variable in form and from a commercial viewpoint so inferior in shape that it would seem wise to remove this fruit in thinning. In the early stages of growth it can be easily distinguished from other fruits in the cluster. Fruits from blossoms 4-5 were most constant in form and most desirable from the standpoint of appearances. Fruits from blossoms 1-3 were really too flat to be rated as of good commercial form.

Wealthy fruits from blossom 6 were best in form and general appearance and they also seemed to be better matured and stood up best in storage. Fruits from blossoms 1-3 presented the poorest appearance.

Blossoms 6 produced the best fruits in Arkansas. The fruits were larger, more regular in shape, and the stem so short in most cases as to eliminate the possibility of stem punctures in packing. It was also observed that, in this variety, russet was entirely absent from the basin of apples which developed from the center flower and usually present in the case of fruits from other flowers of the cluster.

The data secured account for some of the variations observed in describing and judging apples and really bring up the question of typical varietal form. Measurements do not express these differences adequately. One must see the fruits to appreciate the marked range of variation. The results also indicate why form, length of stem and some other characteristics may apparently fluctuate in a given variety. For instance, the center blossom usually sets the fruit that is most likely to survive in the struggle for existence, but if an untimely frost should injure this blossom and not the others, as sometimes happens, the variety would then appear to bear a more oblate apple with a longer stem. As there is a variation in the time at which the flowers in any particular cluster open, weather conditions may favor the setting of fruit from one of these groups of flowers and in this way have an indirect influence upon form. We have actually observed instances where the center blossoms of clusters in the lower parts of large trees were killed by frost while the center blossoms in the upper part of the tree escaped injury. Such a tree would most likely bear longer specimens in the top than in the bottom of the tree during that particular season. But such a variation would not necessarily be constant and might even be reversed another season. To say the least, the position of the fruit in the fruit cluster is a factor that must be considered in studying variations in apples and in some varieties it, no doubt, is a factor worth considering in thinning.

COLOR DEVELOPMENT AND MATURITY OF A FEW FRUITS AS AFFECTED BY LIGHT EXCLUSION.

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INTRODUCTION.

Color is more or less restricted—stating the restriction in different terms—to blossoms, to fruits, to particular species, or to seasons.

For the most part colors may fall into two groups with varying degrees of intensity and intermediate shades, namely, yellows and reds. These colors are produced by two groups of pigments essentially different in chemical and physical properties. These pigments, however, are frequently blended in the same tissue.

The yellow pigments occur in the chlorophyll bodies of the cells. They are present in conjunction with the chlorophyll of healthy tissue, but frequently they seem to increase in quantity as the chlorophyll disappears.

They belong to a group of substances often known as xanthophylls. These are carotin-like compounds, that is, they are related to carotin, the orange or orange-red pigments of the carrot root. Carotin-like bodies are responsible for the orange and orange-red colors in a large number of blossoms and fruits.

These pigments do not occur in solution in the cell sap, but may be present either in the healthy chlorophyll plastides or outside of them. In the latter case they form crystals or are in solution in droplets of fatty oils.

Carotin-like compounds are more permanent than chlorophyll so that any green tissue may exhibit a yellowish color upon the gradual disappearance of the chlorophyll.

The yellow colors of tissue may then be due both to a greater visibility of the yellow in the chlorophyll body when the chlorophyll disappears, and also to actual increased development of carotin-like compounds.

The red pigments are cell sap colors, substances soluble in the aqueous solution constituting plant juices. While there is a great deal of controversy regarding the chemical nature of the red pigments, they are by some authorities supposed to be tannoid compounds, and are generally referred to as anthocyanin. The pigments of red apples, purple grapes and similar colors in all the fruits which have been studied are due to anthocyanin. The reds and the purples are claimed to be a result of the formation, or increased formation, of tannoid compounds.

To some workers it appears that the production of red colors in many species is related to the sugar content. Color may be induced or heightened in the shoots of some plants by growing them for a time in strong sugar solutions. Moreover, cool weather has been found to be generally favorable for the accumulation of sugar in the tissues. And observation indicates that after a season of favorable growth, a cool, protracted autumn with sunshiny days and chilly nights results in more intensive coloration. Of course severe early frosts are disastrous to the brilliancy of colors. Maturity and light are two additional big factors influencing color development in fruits.

SCOPE OF THE EXPERIMENTS.

The experiments were conducted with the idea of determining some of the effects of light exclusion upon color development and maturity with a number of the more commonly grown deciduous fruits.

METHOD OF CONDUCTING THE EXPERIMENTS.

In effecting light exclusion the fruits were covered with sacks made of a medium grade, closely woven black sateen. The sizes of the sacks varied from 5 by 7 inches to 7 by 9 inches and each was provided with a draw string.

The sacks were slipped on over the fruit and the draw string pulled tight. When specimens were double sacked, a second sack was slipped over the first one.

FRUITS SHOWING COMPLETE INHIBITION OF COLOR DEVELOPMENT WITH
CONTINUOUS LIGHT EXCLUSION.

About fifty different varieties of apples, pears, peaches, nectarines and apricots were sacked with single black cloth sacks. The sacks were put on early in the development of the fruit before any color was apparent upon the epidermis, and allowed to remain until the fruit was dead ripe or had to be picked because of frost.

With only one exception no red color developed on the specimens under the sacks. Only so far as light reaches the epidermis does red color develop on the apple, pear, peach, nectarine and apricot. Whenever the sacks became torn, or the size of the fruit stretched the cloth so the light penetrated, color developed in exact outline of the openings.

Table No. 1 shows the effect of continuous light exclusion upon color development with a few varieties of apples.

The one exception in developing color was the Williams apple. With this variety by the last of August the sacked specimens showed splashes and stripes of red with a yellow ground color. The surface of the exposed specimens was completely covered with a dark red color by the middle of August. The fibro-vascular bundles of the exposed specimens were red stained, and the flesh surrounding them was streaked with red. The fibro-vascular bundles of the sacked specimens were not red stained and the flesh was white throughout.

The Roxbury and Golden Russet developed russet in a normal manner under the sacks, although no bronze red color developed on the cheeks.

The development of the scarf skin was not inhibited by light exclusion.

EFFECT OF CONTINUOUS LIGHT EXCLUSION UPON COLOR DEVELOPMENT WITH A FEW VARIETIES OF APPLES.

Variety	Treat-ment	No of Specimens saked	Stage of development at time of sacking	Date of removal of sacks	Observations.
Tompkins King	Single black cloth sacks	25	$\frac{1}{2}$ to $\frac{3}{4}$ inch in diameter	June 29 1916 Oct. 21 1916	No red surface. Ground color white to pale yellow.
Baldwin	Single black cloth sacks	40	$\frac{1}{2}$ to $\frac{3}{4}$ inch in diameter	June 29 1916 Oct. 21 1916	No red color developed. Ground color very pale yellow or white near stem end and one side (unexposed) shading into dark green near calyx and on other side (exposed)
Large Red Siberian Crab	Single black cloth sacks	20	2-3 full size hard and green in color	July 12 1917 Nov. 2 1917	No red developed—yellow in color. Unsacked specimens brilliant red color.
Roxbury and Golden Russet	Single black cloth sacks	10	1-3 to $\frac{1}{2}$ full size. Bronze bluish on sunny side	July 12 1917 July 16 1917	Scarf skin also developed under sacks upon varieties which characteristically develop scarf skin. Russet developed under sacks, but no red color. Dull red side on exposed specimens.
Williams	Single black cloth sacks	20	1-3 full size firm green ground color. Bronze bluish on sunny side	July 16 1917 Aug. 20 1917	Sacked specimens show splashes and stripes of red with yellow ground color. Flesh white with no streaks of red. Exposed specimens dark red and flesh streaked with red.

List of additional varieties which showed no color development on sacked specimens: Rockland, Westfield, Winesap, Yellow Bellflower, Cooper Market, Ben Davis, Bietighimer, Banana, Chenango, Fallawater, Gano, Queen, Hyslop, Large Yellow Sebago and Escoblot, and Clairgeau, Anjou and Clapp pears.

EFFECT OF LIGHT EXCLUSION ON COLOR PRODUCTION DURING DIFFERENT
STAGES OF DEVELOPMENT OF APPLES.

Black cloth sacks were placed over ten specimens and removed from ten specimens of the varieties, Baldwin, Tompkins King and Westfield, at intervals of two weeks beginning from the time the fruit was set until within two weeks of the time they were picked. Every two weeks light was admitted to a set of ten specimens and to a second set light was excluded.

During the last two years the apples could not be kept sacked much later than the 9th of September and have much color develop even though they were then exposed. Likewise September 7th was about as early as apples could be sacked after having been exposed until that time and permit any red to develop.

Table No. II shows the effect of light exclusion on color production during different stages of development of apples.

An interesting thing was observed in the case of Baldwins kept sacked until the middle of August, and then exposed. Where this was done and the specimens were in the direct sunlight the red was intensified as contrasted to the checks. In the shady parts of the tree the treated specimens had a color comparable to the checks without any heightening of the red. The observations were taken September 19 and October 3, the sacks being removed August 15.

EFFECT OF LIGHT EXCLUSION ON COLOR PRODUCTION DURING DIFFERENT STAGES OF DEVELOPMENT OF
TABLE II.
APPLES.

Variety	Treatment	No. of specimens sacked.	Stage of development at time of sacking.	Date of sacking.	Date of removal of sacks.	At time sacks were removed.	Observations Subsequent to removal of sacks.
Baldwin	Single black cloth sacks	10	About size of hulled black walnut	July 7 1917	July 22 1917	Fruit a pale light green under sacks. Bronze bluish on exposed specimens	Aug. 15 fruits unsacked. July 22 have bronze bluish like checks. Sept. 9 and Oct. 3 color comparable to checks
Baldwin	Single black cloth sacks	9	About size of hulled black walnut	July 7 1917	Aug. 15 1917	Fruit under sacks a light green. No bronze. Exposed specimens dull red on one side. About $2\frac{1}{4}$ inches in diameter	Sept. 19. Fruits unsacked on Aug. 15. Red bluish is intensified on specimens where direct sun strikes them as contrasted to checks. In shade the treated specimens have a color comparable to checks. Similar observation noted Oct. 3
Baldwin	Single black cloth sacks	10	About size of hulled black walnut $\frac{1}{2}$ to $\frac{3}{4}$ in. in diameter	July 7 1917	Sept. 9 1917	Fruit covered with sacks, light green. Exposed specimens have a reddish bronze on one side	Oct. 3, 1917, and Oct. 21, 1916. Inner (unexposed) side of apple a very light yellow. Outer side a light green with very dull red. About 5 per cent of surface colored with a dull red
Baldwin	Single black cloth sacks	19		June 29 1916	Sept. 7 1916		
Baldwin	Single black cloth sacks	10	Diameter of apples $2\frac{1}{2}$ inches	Sept. 7 1917	Oct. 21 1917	Red poorly developed. Not more than 6 per cent of surface colored on any specimen. Ground color yellow.	

Similar results were obtained with the varieties Tompkins King and Westfield.

EFFECT OF VARYING THE COMPLETENESS OF LIGHT EXCLUSION ON COLOR PRODUCTION IN APPLES.

To test the effect of varying the completeness of light exclusion double black cloth sacks, single black sacks, red sacks, and white sacks were used in sacking apples. Single black sacks were just as effective as double black sacks, and no color was produced in either case on apples. As would be expected there was about one-half the intensity and amount of color produced under red sacks as on the exposed specimens. Under the white sacks color development took place nearly normally.

Table No. III. shows effect of varying the completeness of light exclusion on color development in apples.

FRUITS SHOWING PARTIAL INHIBITION OR DELAY IN COLOR PRODUCTION WITH LIGHT EXCLUSION.

With the species of plums nearly all varieties showed delay in color production, while some showed a complete non-development of red color when light was excluded.

In the case of cherries some varieties of the same species would show no appreciable effect on red color production, while other varieties would show a marked delay, with only slight red color development. This is shown in Table No. IV on the effect of light exclusion on color production with some varieties of cherries and plums, and in Table No. VI on the effect of light exclusion on maturity.

With grapes and strawberries there was no appreciable effect upon color development. With currants and dark colored gooseberries, and the several varieties of blackberries tested, color development was delayed and somewhat inhibited, as shown in Table No. V on the effect of light exclusion on color production with some varieties of grapes and small fruits.

EFFECT OF VARYING THE COMPLETENESS OF LIGHT EXCLUSION ON COLOR DEVELOPMENT IN
TABLE III.
APPLES.

Variety	Treat- ment	No. of speci- mens	Stage of development of sacking	Date of sacking	Date of removal of sacks	Observations
Tompkins King	Double black cloth sacks	19	Diameter 1 inch. Red bronze burned in cheek.	July 12 1916	Oct 21 1916	No red developed. Ground color, white or pale yellow.
Tompkins King	Single black cloth sacks	18	Diameter 1 inch. Red bronze burned in cheek.	July 12 1916	Oct 21 1916	No red developed. Ground color, white or pale yellow.
Tompkins King	Single red sacks	20	Diameter 1 inch Red bronze burned in cheek.	July 12 1916	Oct 21 1916	Red poorly developed. Splashes of bright red occasionally. Yellow ground color pre- dominant.
Tompkins King	Single white sacks	17	Diameter 1 inch Red bronze burned in cheek.	July 12 1916	Oct. 21 1916	Color similar to apples not sacked. Red a little lighter shade than cheek.

Similar results were obtained with Baldwin apples.

EFFECT OF LIGHT EXCLUSION ON COLOR PRODUCTION WITH SOME VARIETIES OF
TABLE IV.
CHERRIES AND PLUMS.

Variety	Treatment	No. of specimens sacked	Stage of development at sacking	Date of sacking	Date of removal	Observations
Burbank (<i>P. triflora</i>)	Triple black cloth sacks	11	$\frac{2}{3}$ to $\frac{3}{4}$ full size. Green and hard	July 5 1917	Sept. 6 1917	Sacked specimens pale yellow with no red. Flesh a pale lemon yellow. Exposed specimens red to deep red color. Flesh a brownish yellow. Both sacked and exposed ripe.
Wild Goose (<i>P. munsoniana</i>)	Double black cloth sacks	9	$\frac{1}{2}$ to $\frac{3}{4}$ full size. Hard and green.	July 5 1917	Oct. 8 1917	Specimens sacked much lighter red than normal color. Flesh yellow. Exposed specimens were red with red flesh as early as August 31 at which time sacked specimens were a pale yellow.
Wagener (<i>P. americana</i>)	Double black cloth sacks	9	$\frac{1}{2}$ to $\frac{3}{4}$ full size. Hard and green.	July 6 1917	Sept. 7 1917	Sacked specimens colored a faint light yellowish red having flesh light yellow in color and containing no red markings. Exposed fruit was deep dark red by August 15 with flesh rich yellow and marked with red streaks.
Early Richmond (<i>P. cerasus</i>)	Triple black cloth sacks	12	Red, fairly well developed on some species.	July 3 1917	Sept. 9 1917	Sacked specimens light orange red; juice colorless. Exposed specimens were red in color and ready to be picked by July 13.
Windsor (<i>P. avium</i>)	Triple black cloth sacks	11	Fruit all green in color	July 2 1917	July 22 1917	Color developing as on exposed specimens. With a delay of 4 or 5 days in attainment of color due to light exclusion.
May Duke (<i>P. cerasus</i> $\times$ <i>P. avium</i>)	Triple black cloth sacks	12	No red developed	June 20 1916	July 17 1916	All of 38 cherries were a normal red. No effect upon color production.

MICROSCOPIC EXAMINATION FOR COLOR DISTRIBUTION IN SACKED AND CHECK APPLES.

Sections of the epidermis of normal specimens of Tompkins King were prepared and examined microscopically in an effort to determine the nature and distribution of the red and yellow colors. Following is the result of the examinations: (1) *Anthocyanin Color*—The red color is in solution in the cell sap and is of an anthocyanin nature. The anthocyanin color is largely in the sub-epidermal cells with some red color in occasional epidermal cells just below the cutin. The color is primarily confined, however, to the upper three or four layers of epidermal cells except where the color cells run down the fibro-vascular bundles.

YELLOW BODIES OR CAROTIN.

The yellow bodies occur in all the cells of the epidermis and at least $\frac{1}{4}$ of an inch below the epidermal cells. There is no appreciable difference between the number of yellow plastids on the red and the non-red sides of the apple. The yellow color seems to be due to carotin and the carotin appears to be in the form of amorphous granules.

EFFECT OF LIGHT EXCLUSION ON MATURITY AND IN PROLONGING THE PERIOD OF EDIBILITY.

In determining the effect of light exclusion on the normal attainment of maturity with apples, the varieties Primate, Sweet Bough, Golden Sweet, Williams and Yellow Transparent were single sacked with large black cloth sacks on July 12, 1917. These sacked specimens were examined at intervals from August 20 until September 17. There could be noted no delay in the attainment of maturity or in the prolonging of the period of edibleness of any of the varieties of apples tested.

With plums and cherries there was usually a delay of four or five days in the attainment of maturity when the sacked specimens were contrasted with exposed specimens. In some cases there was a prolonging of the period of edibility from five to eight weeks after the crop of exposed specimens had been normally harvested. With the May Duke cherry, however, there was no appreciable influence of maturity resulting from light exclusion (see Table No. 6) nor was there any marked effect in prolonging the period of edibility with this variety. On the other hand, with certain varieties, the cherry was the fruit whose period of edibility could be most prolonged by light exclusion.

SUMMARY.

1. Varieties of apples, pears, peaches, nectarines and apricots develop no color when by means of black sacks light is excluded from specimens of fruit.
2. The development of russet and scarf skin, on varieties normally showing such is not inhibited by light exclusion.

EFFECT OF LIGHT EXCLUSION ON COLOR PRODUCTION WITH SOME VARIETIES OF GRAPES AND SMALL FRUITS.

Variety	Treatment	No. of clusters sacked	Stage of development at time of sacking	Date of Sacking	Date of removal	Observations
Bacchus Moore Early Concord	Double black cloth sacks	10	Hard and green, no color development	Aug. 17 1917 Aug. 16 1916	Oct. 13 1917 Oct. 5 1916	Color of sacked grapes identical with unsacked clusters
McAlpine (Strawberry)	Double black cloth sacks	14	Berries green in many stages of development	June 20 1916	July 17 1916	Red developed berries ripe and normal
Mesereau (R. nigrob)	Double black cloth sacks	9	Berries green with no color apparent	July 20 1916	Aug. 31 1916	70 per cent of berries in sacks were black in color. Some drupelets of 30 per cent berries were reddish in color. Color production inhibited as result of delaying of maturity.
Diploma (R. rubrum)	Single black cloth sacks	11	Fruit green in color	June 20 1916	July 25 1916	The most highly colored specimens under sacks had a much paler red color than unsacked. No specimens were 60 per cent as intensely colored as checks. In some specimens little or no red developed.
Houghton (R. oxyacanthoides)	Single black cloth sacks	11	No red developed	June 20 1916	Aug. 13 1916	Berries under sacks had approximately $\frac{1}{2}$ the intensity of color of the checks

TABLE VI. EFFECT OF LIGHT EXCLUSION ON MATURITY.

Variety	Treatment	No. of sacks	Stage of development at time of sacking	Date of sacking	Date of harvest normally	Date of removal	Observations
English Morello (P. cerasus)	Triple black cloth sacks	7	Fruit hard and green. Some specimens have a faint bronze bluish	July 3 1917	Crop picked Aug. 13. Period of edibility prolonged 1 month	Sept. 15 1917	Sacked fruit well colored with red flesh and red juice in good condition to eat. No inhibition in color production. Colored by Aug. 13.
Early Richmond (P. cerasus)	Triple black cloth sacks	18	Red fairly well developed on some specimens	July 3 1917	July 13 crop picked	Sept. 1 1917	Sacked specimens light pale yellow in color. Now acid and edible. Period of edibility prolonged 6 weeks.
Windor (P. avium)	Triple black cloth sacks	16	Fruit all green in color and firm	July 2 1917	Crop ripe July 25	Sept. 21 1917	Sacked fruit firm, good flavor, deep red color, a prolonging of period of edibility for 2 months.
Valdimer (P. cerasus)	Single black cloth sacks	9	No red developed	July 20 1916	Aug. 5 1916	Oct. 5 1916	Dark red color. Flavor normal. Fruit in good condition. Prolonging edibility 2 months.
May Duke (P. cerasus x P. avium)	Single black cloth sacks	12	No red developed	June 20 1916	July 10 1916	July 17 1916	No appreciable influence upon color production or maturity.
Wild Goose (P. munsonia)	Double black cloth sacks	10	Hard and green, $\frac{1}{2}$ to $\frac{3}{4}$ full size	July 5 1917	Aug. 27 1917	Oct. 8 1917	Specimens under sacks very light red and firm and edible. Period of edibleness prolonged about 5 weeks.

3. If light was excluded later than the first week of September very little color would develop hereafter even though they were then exposed. Likewise, if exposed apples were sacked permanently even as late as the first week in September very little red color would be showing at the time of harvest.

4. Apples enclosed in either double or single black cloth sacks developed no red color. When enclosed in red sacks the amount and intensity of the red color produced on such specimens was about one-half that found on normal exposed specimens. Specimens in white sacks produced red color nearly normally.

5. The effect of light exclusion upon color development with several varieties of plums, cherries, currants, dark-colored gooseberries and blackberries, varied. In some cases the development of red color was completely inhibited, in some color development was checked or delayed, and in other cases color development was not appreciably influenced.

6. As a result of microscopic examination of fresh material the following points regarding the nature and distribution of color in apples were noted: (a) The red color is in solution in the cell sap and is of an anthocyanin nature. It is largely in the upper three or four layers of epidermal cells, although the layer of cells immediately below the cutin has not as much color as the second and third layers of cells; (b) The yellow bodies or carotins occur in all the epidermal cells and at least $\frac{1}{4}$ of an inch into the flesh or tissue below. The yellow plastids appear to be equally distributed throughout the epidermal and sub-epidermal cells becoming, however, less in number as the layers become farther removed from the epidermis.

7. Light exclusion has no effect upon the attainment of maturity or in prolonging the period of edibility of apples.

8. With some varieties of plums and cherries there was a delay of four or five days in the attainment of maturity due to sacking and a prolonging of the period of edibility for from five to eight weeks after the crop of exposed fruit had been normally harvested. On the other hand, there were a few varieties of cherries and plums whose maturity or period of edibility was not appreciably affected by light exclusion.

FACTORS INFLUENCING RATE OF DISCHARGE AND THE DISTRIBUTION OF SPRAY NOZZLES.

By H. L. CRANE, *University of West Virginia, Morgantown, W. Va.*

The idea of testing spray nozzles is not new, as it seems to have originated in 1892 with Woodworth of California, who at that time published an account of a nozzle-testing machine, but unfortunately his results remain unpublished.

Other early investigators of spray nozzles were Booth, then of Missouri, whose conclusion was that a general all-purpose nozzle did not at that time (1900) exist. Faurot, of Missouri Fruit Experiment Station, made several tests on shape of spray discharged as well as size of drops.

He found that the size of the orifice may be the governing factor in the size of the drops discharged. The larger the orifice the larger the drops. Riley, of Cornell, later designed and built a machine for testing spray nozzles which worked on the order of a focal plane shutter; this he called a "sprayograph." A modification of this was used in securing the results in this study. Goodwin, of Ohio, tested about 60 nozzles on a machine similar to the one mentioned. He found that most of the nozzles discharging a hollow cone-shaped spray distributed most of it at one side of the cone; this, he said, could be overcome by using more supply holes in the directing disc. The angle of discharge was found to increase as the depth of the eddy chamber decreased. The size of the orifice was found to have much to do with the rate of discharge, but was not an absolute index. Still later Hewitt, of Arkansas, made a large experimental nozzle, the dimensions of which could be varied. His results were, the narrower the eddy chamber the narrower the angle of discharge. The deeper the eddy chamber the narrower the angle of discharge. A thick disc was found to narrow the ring of spray, but had no effect on angle of discharge, although it made the spray particles larger. The total volume discharge was found to vary with two things, size of orifice and depth of eddy chamber, a larger orifice or a deeper eddy chamber increasing the rate of discharge. There are several other investigators who have contributed to our knowledge of spray nozzles, the work of whom cannot be taken up at this time.

DEVELOPMENT OF THE EDDY CHAMBER NOZZLE.

The history of the development of spray nozzles is very interesting, but long, unfortunately, and only a very brief review will be given. In the early history of spraying solid stream and modified solid stream nozzles were used exclusively until 1880. While doing some spraying for the United States Department of Agriculture William S. Barnard conceived of the idea of making the material whirl before entering the outlet orifice. The results of his ideas produced the Vermorel nozzle as we know it today. From 1884 until 1904 the Vermorel nozzle was used extensively. At the latter date there was a demand for a nozzle which would produce a finer spray at a wider angle, and be of larger capacity. The Gould Manufacturing Company, in response to this demand, conceived the idea of widening the eddy chamber. After numerous experiments they put on the market the Small Sized Mistry and Large Sized Mistry nozzles, which were a great improvement over the Vermorel and were widely used. In a few years power sprayers came into use and demanded nozzles of larger capacity. Again the Gould Manufacturing Company took up the work and in August, 1906, put out a nozzle called the Mistry Junior, which contained a new principle in nozzle construction. This was the directing disc or basal plate which contains the oblique holes that give the material its whirling motion. This was the origin of the disc type of spray nozzles. Other manufacturers took up the idea and soon there were numerous nozzles of similar construction on the market.

APPARATUS USED IN THE STUDY OF DISTRIBUTION OF THE SPRAY.

As stated before, a machine working on the principle of a focal plane shutter was made in such a way that a curtain having a three-inch aperture revolved on two rollers. A sheet of paper was suspended between the rollers. A uniform exposure of about one-fourth second was used, and a pressure of seventy-five pounds at the pump was maintained.

The writer found there were so many factors influencing distribution and rate of discharge that only the more important can be very briefly considered in this paper.

INFLUENCE OF OUTLET ORIFICE ON DISTRIBUTION.

An increase in the diameter of the outlet orifice increases the angle of discharge, but an increase of 4 mm. may, as in the case of the Friend Regular nozzle, increase the angle of discharge three degrees, while another nozzle with the same increase will cause the angle of discharge to be nine degrees wider, as is illustrated by the Tiger Strainer nozzle. Thus no general statement can be made regarding the results that might be expected from a definite increase in the size of the orifice. However, as the area of the orifice is increased, the angle of discharge is not correspondingly widened. When the orifice of the Tiger Strainer nozzle is increased from 1.2 mm. to 1.6 mm., an increase in the angle of discharge of 46.21 per cent per square millimeter of orifice was secured, and when the orifice was changed from 1.6 mm. to 2.0 mm. the increase in the angle of discharge was only 26.0 per cent per square millimeter of orifice. Thus there was a decrease of 20 per cent in the rate of widening of the angle of discharge due to the larger orifice.

As the angle of discharge becomes greater the width of the ring becomes wider and follows the increase or decrease of the angle of discharge.

It has often been said that increasing the size of the orifice, all other things being equal, produces a coarser spray. The results secured do not bear this statement out, as in no case could any appreciable difference be noticed.

TABLE I.

Name of nozzle.	Diameter of orifice in millimeters	Diameter of cone in inches	Width of ring in inches	Angle of discharge	Percent increase per sq. mm. of orifice
Friend Regular	2.0	16	4.0	33.5	0.00
" "	2.8	19	4.5	38.0	6.21
" "	3.2	21	5.0	41.0	5.58
Tiger Strainer	1.2	12	3.5	26.0	0.00
" "	1.6	17	4.0	35.0	46.21
" "	2.0	22	4.0	42.0	26.00

INFLUENCE OF PRESSURE ON DISTRIBUTION.

The angle of discharge was found to be increased as is the pressure up to a certain point, depending on the nozzle, where additional pressure has no effect except in breaking up the spray. The Mistry Junior nozzle

reached its maximum of efficiency at 125 pounds pressure so far as the diameter of the cone is concerned.

The width of the ring was found to decrease as more pressure was applied and, like the angle of discharge, reached its minimum width at the same pressure. As more pressure was applied the spray was broken up finer.

INFLUENCE OF DEPTH OF EDDY CHAMBER ON DISTRIBUTION.

By increasing the depth of the eddy chamber the angle of discharge was decreased and the width of the ring became narrower. There were many more mist-like particles distributed in the center of the hollow cone as the depth of the eddy chamber was increased, while the drops in the ring became somewhat larger. This is what would be naturally expected as any factor which would tend to cause the spray discharged to become a solid stream would also cause the drops to be larger.

INFLUENCE OF WIDTH OF EDDY CHAMBER ON DISTRIBUTION.

The width of the eddy chamber was found to widen the angle of discharge to increase the width of the ring, and if there is any difference to produce smaller drops.

INFLUENCE OF ANGLE OF SUPPLY HOLES IN THE DIRECTING DISC ON DISTRIBUTION.

The angle at which the supply holes are placed in the directing disc greatly affect the distribution of the spray discharged. In the case of the Mistry Junior nozzle a change in the angle of the supply holes of 15 degrees changed the angle of discharge as much as six degrees. The greater the angle of the supply holes the narrower the angle of spray and the ring of spray. The spray particles were smaller in size due to the lesser angle of the supply holes as a greater breaking up was secured. See Table II.

TABLE II.

Name of nozzle.	Diameter of orifice in millimeters	Angle of supply holes	Diameter of cone in inches	Width of ring in inches
Mistry Jr.	1.2	45	32	8
" "	1.2	60	28	7
" "	2.5	45	44	9
" "	2.5	60	36	8

INFLUENCE OF CENTER SUPPLY HOLE IN DIRECTING DISC ON DISTRIBUTION.

Several nozzles now on the market have a central supply hole which is drilled vertically through the directing disc in addition to the oblique holes. It was found that this central supply hole filled up the center of the cone, thus making a solid cone, as is shown in Table 3. The angle at which the spray is discharged is decreased, due to the central hole, and the spray particles are somewhat larger.

TABLE III.

Name of nozzle.	Diameter of orifice in millimeters.	Central supply hole 1.2 mm. in diameter.	Diameter of cone in inches.	Width of ring in inches
New Eclipse	2.0	Open	34	34
" "	2.0	Closed	36	7
" "	2.8	Open	40	40
" "	2.8	Closed	44	8

A few words of explanation as to the possible reason for this may be worth while. In the formation of the hollow cone the oblique holes in the edge of the directing disc cause the material to whirl in the eddy chamber and in leaving the nozzle the material rolls over the edges of the orifice. When a central hole is placed in the directing disc with the oblique holes, the material then flows in two general currents, one whirling around and around, the other flowing outward. Thus a solid cone is produced and the angle of discharge decreased due to the current flowing outward overcoming some of the influence of the oblique holes.

INFLUENCE OF NUMBER OF SUPPLY HOLES IN THE DIRECTING DISC ON DISTRIBUTION.

To make the distribution more even Goodwin suggested placing more holes in the directing disc. The results secured indicate that two holes of the proper dimensions distribute the spray as evenly as more would do it. By using more holes the spray is discharged at a narrower angle, the width of the ring is narrower and but very little difference, if any, could be noticed in the size of the spray particles.

INFLUENCE OF A POST ON THE DIRECTING DISC ON DISTRIBUTION.

A few nozzles now on the market have a raised place at the center of the directing disc which has been called by the writer a "post" as this term seems to describe it best. This post was found to narrow the angle of discharge as well as the width of the ring, as is shown in table 4. Another marked influence of the post is that it causes a much more even distribution of the spray and in this way some of the slight mechanical imperfections of the nozzle are overcome.

TABLE IV.

Name of nozzle.	Position of post.	Diameter of cone in inches.	Width of ring in inches.
Whirlpool	Present	24	7
"	Absent	26	8

INFLUENCE OF THICKNESS OF DISC ON DISTRIBUTION OF THE SPRAY.

The thickness of the disc or of the metal surrounding the outlet orifice was found to exert a very great influence on the distribution of the spray discharged. Increasing the thickness of the disc from 0.5 mm. to 1.0 mm. decreased the angle of discharge as much as nine degrees and narrowed the ring of spray two inches. The size of the spray particles dis-

charged were larger due to the thicker disc. The results secured indicate conclusively that the thickness of the disc is one of the most sensitive factors studied, as a very slight change is capable of producing a very decided change in the distribution of the spray.

OTHER FACTORS INFLUENCING DISTRIBUTION OF THE SPRAY.

Burrs in the outlet orifice, orifices that are oblong in shape, or were not properly centered, or fit so loose in the cap that they would slip so as to be off-center; cracks near the holes in the directing disc, and general lack of care in machining the parts of the nozzles, are responsible for much of the imperfections shown in the distribution.

FACTORS INFLUENCING RATE OF DISCHARGE.

In making a study of the factors influencing the rate of discharge the nozzles were placed in a tightly covered tank fitted with valves and pressure gauge. City water pressure was used. By means of the valves any desired pressure up to one hundred and twenty pounds could be secured. As before, the different dimensions of the nozzles were changed by substituting parts from other nozzles or by making them. Triplicate tests were made and the discharge measured in graduated flasks.

INFLUENCE OF OUTLET ORIFICE ON RATE OF DISCHARGE.

The diameter of the outlet orifice was found to have the greatest influence on rate of discharge of any of the factors studied. It was found that nozzles of the disc type having similar construction vary greatly in their rate of discharge. For example, a variation of more than one hundred liters per hour was found between nozzles having an orifice of two millimeters in diameter. An increase in the area of the outlet orifice does not correspondingly increase the rate of discharge, and the formula $q = A\sqrt{2gh}$ used for finding the discharge for small nozzles cannot be applied to nozzles of the disc type. Due to the great variation in the rate of discharge of this type of nozzles no formula can be given.

INFLUENCE OF PRESSURE ON RATE OF DISCHARGE.

At low pressures the rate of discharge increases rapidly, and as the pressure is increased a smaller increase in the rate of discharge is secured. The regular curve secured in this way suggested to the writer that the curve for discharge might be a square curve, if so, then by the formula $V = \sqrt{K \times P}$, the rate of discharge might be determined for any pressure, which would aid materially in the selection of a nozzle for special purposes. Squaring the volume discharged and plotting the curves it is found they are not straight and do not pass through the origin, and thus cannot be used. A study of the influence of pressure shows that when the pressure is doubled the rate of discharge is increased one and four-tenths times.

INFLUENCE OF DEPTH OF EDDY CHAMBER ON RATE OF DISCHARGE.

Increasing the depth of the eddy chamber has always been considered to increase the rate of discharge. The results secured indicate that there are exceptions to the rule. The scientific nozzle gave a decrease in rate of discharge when the eddy chamber was made deeper, but began to increase after a certain depth was reached. This was found to be true of nozzles which have the supply holes in the directing disc at practically no angle. The increase in rate of discharge due to the depth of the eddy chamber was found to vary with the size of the outlet orifice.

INFLUENCE OF WIDTH OF EDDY CHAMBER ON RATE OF DISCHARGE.

Former investigators have found that the width of the eddy chamber exerted very little influence on the rate of discharge. In the case of the Friend Regular nozzle, an increase in the rate of discharge was secured when the eddy chamber was made wider, the increase varying inversely with the diameter of the orifice. Very little difference was secured with other nozzles when the width of the eddy chamber was increased.

INFLUENCE OF AREA OF SUPPLY HOLES IN THE DIRECTING DISC ON RATE OF DISCHARGE.

One of the chief reasons for nozzles having orifices of the same size having such a great variation in the rate of discharge, is due to the area of the supply holes in the directing disc. Increasing the area of the supply holes increases the rate of discharge, which varies with the area of the orifice as is shown in Table 5. The Friend Regular and Friend Calyx nozzles are alike in every respect excepting area of supply holes. What is true of these nozzles was found true of all the nozzles tested.

TABLE V.

Name of nozzle.	Diameter of orifice in millimeters.	Area of supply holes in millimeters.	Percent increase in rate of discharge.
Friend Regular	2.0	25.1328	
Friend Calyx	2.0	75.3984	29.9
Friend Regular	2.8	25.1328	
Friend Calyx	2.8	75.3984	46.3
Friend Regular	3.2	25.1328	
Friend Calyx	3.2	75.3984	51.9

INFLUENCE OF CENTRAL SUPPLY HOLE IN DIRECTING DISC ON RATE OF DISCHARGE.

- A very small hole placed in the center of the directing disc was found to have a great influence on the rate of discharge and, as was pointed out in the remarks on distribution, the presence of this hole changed the character of the spray from a hollow cone to a solid cone, and thus we would expect a greater rate of discharge. A small hole exerts more influence than does a large one, and if the area of the supply holes in the

edge of the directing disc is large the influence of the central supply hole is reduced. On the average the increase in rate of discharge is much greater when the hole is placed in the center of the directing disc than would be obtained if the same area was placed at the outer edge of the disc.

INFLUENCE OF ANGLE OF SUPPLY HOLES ON RATE OF DISCHARGE.

On the average an increase in the rate of discharge of about 2 per cent was secured for each degree that the angle of the supply holes was increased. This is what would be expected, as the holes at a greater angle tend to decrease friction and loss of pressure, the spray material not losing so much of its energy against the side walls of the eddy chamber and having a more uninterrupted outward passage to and through the orifice, thus increasing the rate of discharge.

OTHER FACTORS INFLUENCING THE RATE OF DISCHARGE.

A post on the directing disc may increase the rate of discharge as much as 5 per cent, as was found in the case of the Whirlpool nozzle. This must be due to the whirling material being kept to the outer edge of the directing disc and thus preventing any conflicting currents which would increase friction.

A disc 0.5 mm. in thickness was found to increase the rate of discharge a little more than 1 per cent over a disc 1.0 mm. thick, this being due to the contraction of the discharge vein at some point.

Faulty outlet orifices were found to increase or decrease the rate of discharge, depending on the nature of them.

This briefly outlines the work done and some of the results secured in a study of the factors influencing the distribution and rate of discharge of the disc type of spray nozzles.

THE EFFECT OF ADJACENT LEAF AREA ON THE SUGAR CONTENT OF ORANGES.

By J. ELIOT COIT, *University of California, Berkeley, California.*

In discussions on pruning fruit trees the point is often made that the perfect development of individual fruits on the trees is largely dependent upon the proximity of an adequate leaf area. Some horticulturists appear to have taken it for granted that the larger the area of healthy leaf-surface near the given fruit the better off the fruit is. Recently, however, physiological studies have emphasized the fact that a large leaf area, while capable of forming large quantities of carbohydrates, may at the same time interfere with the development of the fruit by appropriating a part of the water supply needed by the fruit. Under the stress of abnormally rapid transpiration it is possible for a large leaf area to furnish a stimulus which may result in actual abscission of young fruits. It fol-

lows, therefore, that there must be a certain optimum leaf area for the best development of each individual fruit.

In considering this problem the question naturally arises as to the extent to which the fruit is limited in its acquisition of carbohydrates to the supply manufactured in its immediate vicinity. Is a given terminal fruit under any handicap in acquiring carbohydrate material from beyond its mother branch or from the general store of the plant? If such is the case it would be reasonable to suppose that the sugar contents of fruits would be reduced by the early removal of all leaves in their vicinity even though the epidermis of the fruits themselves might contain a certain amount of active chlorophyll.

In order to test this point an experiment was performed on Washington Navel orange trees in an orchard at Edison, California.

A number of healthy young fruits about one-half inch in diameter and which terminated leafy shoots was selected. From a large number of measurements it was found that the average leaf area of the current season's growth was 50.188 square centimeters. These shoots were then divided into four classes and treated as follows:

Class A. Check. Not treated.

Class B. One-third leaf area removed, beginning at base of fruit.

Class C. Two-thirds leaf area removed beginning at base of fruit.

Class D. All leaf area of current season removed, leaving a bare twig not less than eight inches long.

The resulting fruits were picked at maturity, and the juice from all the fruits of each class was extracted and mixed. The juice was then tested for total solids with the following results:

	Number of fruits harvested.	Average weight in ounces.	Total solids percentage by Brix Spindle.
Class A	29	8.00	11.3
Class B	19	6.38	11.1
Class C	37	7.11	11.7
Class D	21	7.42	11.1

While the largest fruits occurred in Class A, those in Class C which had two-thirds of the leaves removed contained the most sugar. These differences, however, are so slight as to be well within the normal range of variation, as the fruit from different trees in this orchard often varies as much as 2 per cent in total solids.

We, therefore, seem justified in concluding that in the case of navel oranges growing under the environment of Edison, California, the fruits are capable of developing to average size and storing up their full quota of sugar and other carbohydrates without any leaves being nearer than eight inches. Apparently such fruits have as ready access to the common supply of food in process of translocation through the trunk and large branches as they have to that which is manufactured in their immediate vicinity.

FRIDAY, DECEMBER 28, 9:30 A. M.

EXPERIMENTAL WORK ON SELF-STERILITY OF THE APPLE.

By W. H. ALDERMAN, *University of West Virginia, Morgantown, W. Va.*

The purpose of this paper and that of Dr. Knight's is to report the progress of an experiment in the study of the self-sterility of the apple as it grows in West Virginia. The first paper will contain a brief account of the results of the field tests and the second will deal largely with the physiological side of the question.

The study was begun in the spring of 1912. Prior to this time the work of a number of investigators indicated that most fruits were more or less self-sterile and recent work by Lewis and Fletcher presented considerable evidence to show that self-sterility was largely the condition in the two great groups of pomaceous fruits, the apple and pear. The attention of the writer about that time was directed to the fact that there were reasonably productive orchards in the state made up of plantings of single varieties, notably Rome Beauty, a variety said to be self-sterile. Baldwin orchards in Western New York were known to the writer to be consistently productive and yet were so located that they must have been almost entirely self-fertilized. It was to explain such apparent contradictions that the work was begun.

Until this time the work of investigation in apple pollination and sterility had for the most part consisted of the study of bloom clusters enclosed in paper sacks, and in the case of cross fertilization emasculation had usually been practiced. At least four possible sources of error entered into such tests. First, the conditions within paper sacks were abnormal from the standpoint of temperature and humidity; second, individual flowers or clusters of flowers were studied without regard to the rest of the tree, whereas in orchard conditions the tree is the unit; third, emasculation of bloom might produce a decidedly abnormal condition and thus affect the results to an unknown degree, and fourth, it had not been shown that pollen from other trees of the same variety might not prove effective, even though a single flower or single tree was self-sterile within itself.

To eliminate these questions, whole trees were enclosed in cheesecloth or muslin frames within which it was thought the conditions would be nearly normal. Then *all* the blooms on an enclosed tree were studied and both cross and self-fertilizations were made without emasculation, which is, of course, the normal method in orchard pollination. For two years we attempted to carry out part of the pollination by means of hives of bees enclosed within the frames. This did not prove very successful, as the bees concerned themselves mainly with trying to escape, and died in large numbers. Vicissitudes of many kinds have beset the experiment. A late freeze destroyed all the work of one year, a short blooming period

handicapped another, while cold weather and storms destroyed a part of the work of two other years. In fact, only three good years out of six have been obtained. Some things worthy of note have been observed and will be summarized in this paper and that by Dr. Knight.

CONDITIONS WITHIN THE FRAMES.

The muslin frames proved very satisfactory (cheesecloth was too light) and maintained conditions very near to normal. Temperature within the frames was somewhat less variable than that without, being from 1 degree to 2 degrees higher at night and 2 degrees to 4 degrees lower on sunny days. On cloudy days there was little difference. Humidity records taken within and without the frames by means of wet and dry bulb thermometers showed a slight increase within the frames, but the difference was not great and frequently was indiscernible. Some mechanical protection from the winds was afforded so that conditions for setting were seemingly somewhat more favorable within than without the frames.

COMPARISON BETWEEN PAPER BAGS AND MUSLIN COVERED FRAMES.

In order to have a means of comparison of our work with that of others using paper bags we ran a small comparative test of the two methods. Somewhat to our surprise, the paper sacks gave the better results as far as per cent of set was concerned.

SET OF FRUIT UNDER FRAMES AND PAPER BAGS.

CROSS	Frames			Paper Bags		
	No. Bloom	No. Set	Per cent Set	No. Bloom	No. Set	Per cent Set
Rome Beauty selfed	10730	109	1.01	658	9	1.36
Rome Beauty X York Imperial	5301	62	1.14	527	70	13.28
Rome Beauty X Ben Davis	463	2	.43	181	15	8.28

We are at a loss to satisfactorily explain the marked difference in favor of the paper bags, but at least the fact is established that they do not hinder the setting of fruit. It is possible that the presence of the tightly enclosing paper bag may be responsible for conditions that induce an *abnormal* setting of fruit. The fact that at the time the above records were taken the Rome Beauty trees under orchard conditions, open to miscellaneous pollination, showed only 1.9 per cent set indicates that the paper bags may have given abnormal results. For testing for self-sterility of varieties the bags are a convenience and almost a necessity in case of large trees. Probably, too, they are reasonably accurate where comparative studies only are desired.

During the time the work has been under way, about 150,000 flowers have been pollinated and records kept of their subsequent development. A partial summary of the work with three varieties appears in the accompanying table.

**SUMMARY OF THREE YEARS' WORK WITH ROME BEAUTY, YORK
IMPERIAL AND WAGENER.**

COMBINATION	No. Bloom	No. Set	Per Cent Set
Rome Beauty selfed	13129	162	1.23
Rome Beauty x Rome Beauty	3697	6	.16
Rome Beauty x York Imperial	7808	171	2.19
Rome Beauty x Wagener	1074	35	3.25
Rome Beauty x Ben Davis	1029	29	2.43
Rome Beauty—open	10676	472	4.46
York Imperial selfed	16645	94	.56
York Imperial x York Imperial	5097	35	.68
York Imperial x Rome Beauty	5885	499	8.47
York Imperial x Wagener	2572	294	11.43
York Imperial x Ben Davis	1326	84	6.33
York Imperial—open	15992	1260	7.87
Wagener selfed	2563	31	1.20
Wagener x Wagener	844	12	1.40
Wagener x Rome Beauty	1096	97	8.85
Wagener x York Imperial	582	59	10.13
Wagener—open	5315	455	8.50

Inspection of this table reveals the fact that there is no advantage gained by pollinating a variety from pollen of another tree of the same variety. Probably no significance should be attached to the fact that Rome Beauty selfed gave a higher percentage of set than Rome Beauty by another Rome Beauty, since neither of the other varieties offered the same conditions. Theoretically we should expect the same relation between trees of the same variety as between flowers of the same tree, when dealing with trees propagated asexually and whose original source was a single plant grown from a single fertilized germ-cell. But, we have heard much concerning marked changes in form, constitution and function of such plants, secured through the selection of "pedigreed" strains. If such mutative forms are of common occurrence among orchard plants, and since mutations affect the makeup of sex cells as well as body cells, would it not be expected that different individuals of self-sterile varieties might frequently be so modified as to be mutually cross fertile? The above proof to the contrary points to the stability rather than to variability of varieties.

It is interesting to observe that Rome Beauty does not normally set as large a per cent of its bloom as do Wagener or York Imperial. Under orchard conditions, and open to free pollination by several varieties, Rome Beauty set 4.46 per cent, where York Imperial set 7.87 per cent and Wagener 8.5 per cent. From this it is clear that one may not judge the relative sterility of two varieties by direct comparison of percentage of fruit set upon each, but rather by comparison of such set of fruit to the normal set of the variety. In the same way the efficiency of a mutual pollinizer may not be judged by a direct comparison of its effects upon two varieties, but rather by a comparison to the normal set of each. Thus, Ben Davis, in pollinating Rome Beauty, gave only 2.43 per cent set, and in pollinating York Imperial 6.33 per cent, yet it was nearly as efficient upon the former variety as upon the latter.

From a study of the table it is clear that while none of the varieties are entirely self-sterile, they are greatly benefited by cross fertilization. If we summarized the table by throwing together those selfed as pollinated by the same variety and those pollinated by other varieties, the extent of this benefit is more distinctly set forth.

BENEFITS OF CROSS POLLINATION.

Combination.	Number Blooms	Fruits Set	Per cent Set
Rome Beauty not crossed.....	16,826	168	.99
Rome Beauty crossed.....	20,587	702	3.41
York Imperial not crossed.....	21,742	129	.59
York Imperial crossed.....	25,775	2137	8.29
Wagener not crossed.....	3,407	43	1.26
Wagener crossed.....	6,993	611	8.73

In the case of Rome Beauty the percentage of set was increased three and a half times, York Imperial fourteen times and Wagener seven times. This advantage is further greatly augmented when we note that the size of the individual fruits was increased by crossing. The increase in the case of Rome Beauty was 27.8 per cent and in York Imperial 42.7 per cent over the size of the self-pollinated fruits. Records for one year with Wagener showed a slight tendency to reverse this relation, but this was probably due to the fact that only a few selfed fruits set upon a vigorous tree, and these grew to abnormal size. A more detailed expression of the relation of weight of fruit as affected by pollination is contained in the accompanying table:

WEIGHT OF FRUIT AFFECTED BY POLLINATION.

Cross	1911 Ounces	1915 Ounces	Average Ounces	General Average of each Variety
Rome Beauty selfed	..	4.22	4.22	....
Rome Beauty X Rome Beauty.....	3.12	..	3.12	3.67
Rome Beauty X York Imperial.....	6.30	4.07	5.18	....
Rome Beauty X Wagener.....	4.87	5.00	4.93	....
Rome Beauty X Ben Davis.....	....	4.05	4.05	....
Rome Beauty open.....	5.57	3.68	4.62	4.69
York Imperial selfed.....	3.98	2.00	2.99	....
York Imperial X York Imperial.....	3.22	4.08	3.65	3.32
York Imperial X Rome Beauty.....	5.25	4.08	4.66	....
York Imperial X Wagener.....	5.02	4.23	4.62	....
York Imperial X Ben Davis.....	..	3.82	3.82	....
York Imperial open.....	5.72	6.03	5.87	4.74
Wagener selfed.....	6.08	..	6.08	....
Wagener X Wagener.....	4.18	....	4.18	5.43
Wagener X Rome Beauty.....	3.77	..	3.77	....
Wagener X York Imperial.....	3.94	....	3.94	....
Wagener open.....	5.70	....	5.70	4.47

Rome Beauty cross gain over selfed, 27.8 per cent.
York Imperial cross gain over selfed, 42.7 per cent.

EFFECT OF EMASCULATION UPON SETTING OF FRUIT.

It was observed at the beginning of the paper that emasculation provided abnormal conditions that might influence the setting of fruit. During two years a test upon this point was maintained with interesting results noted in the following table:

EFFECT OF EMASCULATION UPON FRUIT SETTING.
PER CENT OF FRUIT SET.

	1914 Emascu- lated Per Cent.	Not Emascu- lated Per Cent.	1915 Emascu- lated Per Cent.	Not Emascu- lated Per Cent.
Rome Beauty X Wagener	8.80	.19	0.00	0.00
Rome Beauty X York Imperial	8.60	.00	2.30	2.90
Rome Beauty X Rome Beauty	.24	.56	0.00	0.67
York Imperial X Wagener	23.70	6.40	0.00	0.00
York Imperial X York Imperial	.39	.75	2.60	0.66
York Imperial X Rome Beauty	12.02	13.80	9.80	3.63
Rome Beauty X Ben Davis	..	..	2.64	1.82
York Imperial X Ben Davis	..	..	8.24	3.07
Average	8.96	3.60	4.29	2.12

Probably further work would be desirable to fully verify the results, but it is significant that for the two years the set of fruit under emasculated conditions was more than double that where no emasculation was practiced. It seemed to make no difference in the results if the entire calyx and corolla were removed, merely the corolla, or if both were left practically intact and only the anthers removed. It is unsatisfactory to vaguely ascribe this increased set to stimulation due to mutilation of flower parts. The term stimulation has been unduly and unwarrantably abused by horticulturists and others who have employed it to explain anything that was otherwise difficult of explanation. The probable explanation of the increased activity in emasculated blooms may be found not in the fact that they were mutilated, but rather that they were protected from superabundant pollination from their own pollen. It is clear that unless a bloom is emasculated it cannot be cross pollinated without self-pollinating it at the same time. Probably self-pollination frequently occurs naturally in such cases before the artificial cross-pollination is brought about. Foreign pollen tubes must then actively compete with many tubes from its own pollen with the result that the chances of cross-fertilization are lessened. That this is actually the case is indicated by two tests in 1915. Two groups of unemasculated Rome Beauty blooms were pollinated by Ben Davis and York Imperial respectively, and, of course, were unavoidably self-pollinated during this operation. At the same time two other groups were self-pollinated and 24 hours later were given a delayed pollination with Ben Davis and York Imperial. In both cases a considerably higher percentage of set was secured from the first series than from the delayed cross. The obvious conclusion is that in the delayed cross the Rome Beauty pollen tubes having a 24-hour lead over those of

the Ben Davis or York Imperial had drawn so extensively upon the food supply of the style and stigma that the foreign pollen tubes were unable to make a vigorous growth. This might allow the tubes of Rome Beauty pollen to reach the ovary first and affect a self-fertilization which might or might not cause full fruit development, but which would destroy the opportunity for a more efficient cross-fertilization. A second possible explanation is found in the fact that Rome Beauty pollen tubes grow very slowly through their own style and only under favorable circumstances do they reach the ovary before degeneration takes place in the egg nucleus. It is conceivable that the pollen tubes from the delayed cross might be delayed in their growth by the numerous Rome Beauty tubes from the first pollination and thus not reach the egg nucleus in time for fertilization.

METHODS OF EMASCULATION.

Before we leave the subject of emasculation it might be well to mention two methods which were found to be rapid and satisfactory. In the first a small section of a fine toothed comb was used. The petals of the unopened flower are quickly removed by one jerk from the thumb and forefinger and then with one or two movements of the comb the anthers are literally raked out without injury to the pistil. It is sometimes necessary to remove alternate teeth from the very fine combs, but the familiar "Jumbo" type is usually all right without alteration. By the second method the flower is grasped firmly and a quick snap with the fingernail just under the edge of the calyx removes calyx, corolla and stamens, leaving pistil and receptacle clean and bare. Some varieties will work much better this way than others.

EFFECT OF CROSS-FERTILIZATION AND SELF-FERTILIZATION UPON SEED.

Mueller Thurgau, in working with apples, found a positive correlation between number of seeds and weight of fruit. We have already noted that cross-pollination as a rule brought about an increase in the weight of fruit. Reasoning from this, the expectation would be that fruit developed by self-fertilization would contain fewer seeds than fruit from cross-pollination. This was true and the distinction was very marked, as the following table indicates:

INFLUENCE OF SELF-FERTILIZATION AND CROSS-FERTILIZATION UPON NUMBER OF SEEDS.

	Seeds per apple.
Rome Beauty—selfed	3.50
Rome Beauty—crossed	7.10
York Imperial—selfed	2.70
York Imperial—crossed	7.00
Wagener—selfed	1.06
Wagener—crossed	6.88

It will be observed that there are from two to six times as many seeds in the crossed fruits as in the selfed ones. This is a far greater dif-

ference than was indicated by the size of the apples, but at the same time shows close correlation between number of seeds and size of apple when group averages are considered. We find the correlation somewhat diminished when we consider individual apples within a single group and when we take a population made up of all apples of a variety regardless of whether they are selfed or crossed, we find the correlation reduced to nearly nothing. In other words, we find self-fertilized fruits with only two or three seeds developing to a greater size than two or three seeded fruits selected from a cross-fertilized group. This may be due to the fact that the self-pollinated trees almost invariably set fruit sparsely and consequently were able to grow to a larger size those fruits which did form. In this connection, it was found that the larger apples always had the larger seed, a correlation of little consequence from our viewpoint, for it is governed by vegetative development rather than by the sex cells.

POLLEN GERMINATION TESTS.

One possible explanation of partial or complete self-sterility is that there may be secreted upon the stigma certain toxic substances which may prevent or retard the germination and growth of the pollen grains and tubes. To satisfy ourselves upon this point, over 200 tests were made in which pollen of several varieties was germinated in a stigmatic extract made from their own stigmas and from stigmas of other varieties. Germination of all the varieties seemed equally good whether the medium was extracted from their own stigmas or from other varieties. In fact, there was no difficulty experienced in getting good germination of apple pollen in the stigmatic extract from cucumber, tomato and geranium blooms. Thus it is evident that sterility is not a result of toxic inhibition of pollen germination.

A PRACTICAL TEST OF STERILITY IN THE ROME BEAUTY.

In 1915 an orchard of Rome Beauty that had been bearing only moderate crops was used for a practical test of the value of cross-pollination. Six hives of bees were placed in a section of the orchard and sixteen trees in a block surrounding them were placed under observation. Large blooming branches of other varieties were brought in and placed upright in pails of water suspended from the trees. The bees worked this block of trees thoroughly and presumably made a great number of cross-pollinations. Another block of 16 trees at some distance was used as a check. The amount of bloom upon both blocks was about equal, being 81 per cent in the bee plot and 83 per cent in the check. Sample counts of about 9,000 blossoms showed a set of 12.6 per cent in the bee plot and 7.8 per cent in the check. In another part of the orchard, where a Ben Davis tree had been planted through a mistake, the set of fruit was 20 per cent on adjacent trees. The sixteen trees fertilized by the bees produced $174\frac{1}{2}$ bushels and the check block $83\frac{1}{2}$ bushels.

In 1916 the test was repeated and records kept upon six trees (the bees were reduced to two hives) and six checks were selected as nearly as

possible identical in size and amount of bloom. The blossoming branches brought in were not in very good condition and the bees were not as active as the year before. A set of 8.3 per cent was secured in the bee plot and 4.3 per cent in the check plot. Yields of fruit were 54 bushels and 51 bushels respectively. Trees near the Ben Davis tree set 15.9 per cent.

These tests indicate clearly the value of bees in an orchard. The trees in the bee plot were unquestionably more thoroughly self-fertilized than in the rest of the orchard, and this fact itself would have probably produced some gain, but it seems clear that this could not adequately explain a percentage of set double that of the normal, hence we believe that the greatest gain was secured by reason of the cross-pollination that must have taken place. That this was the case is unmistakably indicated by the greatly increased set of fruit in the vicinity of the Ben Davis tree. Bee activity was no greater at this point than in the check trees, and yet the set of fruit there was between three and four times heavier than the normal for the orchard, as indicated in the check.

PHYSIOLOGICAL ASPECTS OF SELF-STERILITY OF THE APPLE.

By L. I. KNIGHT, *University of West Virginia, Morgantown, W. Va.*

MATERIAL AND METHODS.

Material was collected at intervals of approximately 24 hours, beginning 24 hours after pollination. It was killed in Gilson's killing fluid, as recommended by A. W. Drinkard (*Fruit Bud Formation and Development*, Proc. Soc. Hort. Sci. 1911), was preserved for study in 70 per cent alcohol.

The work was carried on in co-operation with Dr. A. H. Hutchinson, of the University of British Columbia, and Dr. S. H. Eckerson, of the University of Chicago, who made the microscopical and microchemical studies.

The first study was made chiefly on Rome Beauty pollinated by Rome Beauty, and Rome Beauty pollinated by Jonathan. Material was embedded in paraffin and sectioned thin enough for cytological study. A triple stain (1) iron alum haemotaxylol (2) safranin and (3) lichtgrün was found to give best results.

DEVELOPMENT OF POLLEN "DUCT."

There is no stylar canal, and pollen tubes make their way through the tissue along a more or less well defined path. Decomposition of the cells along this path, or extrusion of material from them, gives rise to what Hutchinson has called "mucilage formation." This so-called mucilage is doubtless nutritive in nature, but also serves as a lubricant for the pollen tube. The "mucilage formation" was more pronounced in Rome Beauty X Jonathan than in Rome Beauty X Rome Beauty. From a mechanical

standpoint the progress of Jonathan tubes seemed to be facilitated while that of the Rome Beauty tubes seemed to be hindered. Further study is necessary on the question of nutrition in the two cases. Fresh material, however, will be required for this, i. e., not leached by alcohol.

DEVELOPMENT OF POLLEN TUBES.

(a) Germination of Grains on Stigma—In Rome Beauty X Jonathan the pollen grains were germinated and empty on the stigma at the end of 24 hours. In Rome Beauty X Rome Beauty, however, many grains on the stigma had not germinated at 24 hours.

(b) Growth of Pollen Tubes—In Rome Beauty X Rome Beauty at 24 hours the contents of the tubes were plasmolyzed, while in Rome Beauty X Jonathan at 48 hours the tubes were vigorous, the tube nucleus near the apex of the tube. In Rome Beauty X Rome Beauty at 91 hours the tube nucleus was drawn back from the apex of the tube.

RATE OF GROWTH.

In Rome Beauty X Jonathan the pollen tubes were found to traverse the length of the style in 48 hours. In Rome Beauty X Rome Beauty the tubes were still on the way down the style at 91 hours and even at 120 hours, while at 120 hours the egg cell begins to show disintegration.

It seems, then, that under the conditions of this experiment the growth of Rome Beauty tubes in Rome Beauty styler tissue is too slow to reach the egg before disintegration begins, i. e., in time for fertilization.

EMBRYO AND ENDOSPERM DEVELOPMENT.

After fertilization the endosperm is first to start development. The embryo in Rome Beauty X Jonathan at 192 hours was 2 to 3 celled, and by 240 hours was many celled.

Further study, chiefly microchemical (by Dr. S. H. Eckerson).

Methods.—The tissue from 70 per cent alcohol was macerated and teased out on the slide as offering the best means of following the course of the pollen tubes. The style was usually split down one side and laid open. The stain used was either resorcin blue or aniline blue. The former gives a deeper stain, but it is not permanent. Aniline blue, on the other hand, gives a fainter stain, but it is more permanent. These stains owe their efficiency to the fact that in dilute solution they stain only callose. The method of using callose stains was employed by Mangin in 1895 in tracing hyphal threads. Later Jost, Molish, Osterwalder and others used the method in tracing pollen tubes and demonstrated the existence of callose plugs in pollen tubes of a number of different species. Callose plugs were shown in the pollen tubes of a number of apple varieties in the course of the present study, and their deep staining with resorcin blue facilitated the tracing of the course of these tubes.

In Rome Beauty X Wagener and Wagener X Rome Beauty a good many fertilizations occurred within 24 hours. Ten were examined of

each cross with 3 or 4 fertilizations. In Rome Beauty X Rome Beauty at 24 hours several tubes had reached the base of the style. Fertilization occurred in a few cases in 48 hours. The effect of conditions on rate of growth is quite marked if we compare results of this study with those of the first study. At moderate temperature (as in the first study) Rome Beauty tubes required 91 to 120 hours to traverse the Rome Beauty style. At high temperature (80-90 degrees F during the day, as in this study) 24 hours only were required to traverse the style in Rome Beauty X Rome Beauty. Perhaps here lies the explanation of self-fertility under certain favorable climatic conditions of ordinarily self-sterile varieties of apples.

A. Osterwalder (Landw. Jahrb. (Berlin) 39 Heft 1-6, 917-998, 1910), reports experiments where 2 days and 4 hours were required for tubes to reach the locules in one variety of apple when cross pollinated.

Rome Beauty Selfed—Further Study—A higher degree of acidity (H-ion concentration) was shown in Rome Beauty X Rome Beauty than in Rome Beauty pollinated with foreign pollen.

There was in Rome Beauty X Rome Beauty a greater content of calcium oxalate crystals and also of crystals that are possibly calcium malate, in as much as they were present in the alcohol-preserved material. Pollen tubes as well as stylar tissue showed great quantities of these crystals (calcium malate?).

Over 300 pollen tubes were found in one style of Rome Beauty X Rome Beauty and as many in each of the other four. Most of these (roughly 275 of the 300) reached only to the base of the stigma, a distance of 1 to 2 mm. Competition for food is suggested. A few, however, do traverse the full length of the style and some even passed beyond the locules to the base of the ovary. It is possible that Osterwalder examined only the former type of short tubes and consequently reached the conclusion that in case of self-pollination of pear and apple the tubes penetrate only 2 to 4 mm. in a style of 10 mm.

ARTIFICIAL CULTURE OF POLLEN.

(a)—*Germination Media*—In our earlier work 8 to 10 per cent cane sugar solution was found to be the best germinating medium. Dr. Eckerson found 3 per cent fructose to give best results with pollen from forced material. Osterwalder found that 5 to 10 per cent cane sugar gave good germination, if a portion of the stigma were present. We found stigmatic extract neither favorable nor inhibiting in its effect when added to sugar solution.

(b) *Accelerating Effect of Asparagin*—Dr. Eckerson found that a trace of asparagin added to 3 per cent fructose solution increased the growth rate and total growth of the pollen tubes. Asparagin was suggested since it was shown to be present in the style,—is in fact one of the most abundant and widely distributed amino acids in plant tissues.

(c) Maximum growth of tubes in artificial culture (fructose and trace of asparagin) was more than the required length to reach from stigma to egg. A maximum length of 10 mm. was attained by about 5 per cent of the tubes. The required length in case of Rome Beauty style is 7 mm. The maximum length was reached in about 2 days. These results are in

marked contrast with those of Jost (Bot. Zeitung. Heft 5 and 6; 77-116, 1907), who claims that he was unable to get in any artificial culture a sufficiently great tube growth to reach from stigma surface to egg.

Pollen grains of different varieties germinated well in distilled water.

Study of Fresh Material (from twigs brought into greenhouse for forcing)—When the pollen mother cell divides, the division walls are at first of callose (in tetrad stage). A thin layer of pectic substance soon enters as a sort of middle lamella and subsequently forms the outer covering of the individual pollen grains. Thus the exine is of pectic substance and the intine is of callose. In the tetrad stage of the pollen mother cell there is just a trace of glucose and a trace of phosphate. Phosphate disappears, but glucose increases in amount until suddenly starch appears in very minute grains. No test was obtained for amino acids at this stage. With germination of grains and growth of tubes, tests showed the presence of glucose, fructose, and sucrose, as well as a trace of asparagin.

Calcium oxalate was found in abundance in the ovary and surrounding tissues of young fruit buds (more than in leaf buds). The calcium-oxalate crystals disappeared as the floral organs developed, in this forced material. This may be compared with the appearance and disappearance of magnesium oxalate in wheat (State Coll. of Washington, Agric. Exp. Sta. Bull. 139, p. 6). There is here a question as to the role of calcium-oxalate in metabolism. Injection of oxalic acid into some plant tissues has been shown by H. C. Sampson (some unpublished experiments) to induce abundant deposition of starch. It suggests a possibility that needs investigation here.

PLUG-FORMATION IN POLLEN TUBES.

As the pollen tube pushes out of the grain, callose stains show that callose forms a lining of the tube. In tubes 3 hours old a ring-like thickening, preliminary to plug-formation, begins. At 5 hours in tubes $\frac{1}{2}$ mm. long, 2 to 4 plugs were starting. In tubes $8\frac{1}{2}$ to 10 hours old and $\frac{3}{4}$ to 1 mm. long, four complete plugs and the beginnings of two more were seen. Within a very brief time the oldest plug is completed, shutting off the protoplasmic contents of the tube from the grain, consequently its subsequent growth must depend almost entirely upon its nutrition in the stylar tissue.

We have previously mentioned the advantage that may be taken of this plug-formation in tracing the tubes down the style.

From our study thus far we may conclude:

(1) Self-sterility of Rome Beauty is not due to sterility of the pollen, as has been shown to be the case in certain varieties of grapes.

(2) Sensitiveness of pollen to overabundant moisture supply is not involved here as a factor, as has been shown by Jost for the pollen of many grasses, barley especially; and by J. N. Martin for the pollen of red clover. The pollen of Rome Beauty and many other varieties germinated well in distilled water.

(3) Rome Beauty stigmatic extract offers no inhibition to the germination and growth of Rome Beauty pollen.

(4) Rome Beauty stigmas offer no particular mechanical obstruction to the penetration of Rome Beauty pollen tubes.

(5) Self-sterility of Rome Beauty is not due to inability of its own pollen tubes to grow deep enough to reach the egg. This has been suggested as the cause of self-sterility in certain pear and apple varieties by the work of Osterwalder.

(6) From present indications one important factor in self-sterility of Rome Beauty is the relatively slow rate of growth of Rome Beauty tubes in Rome Beauty stylar tissue. Doubtless other factors will be found upon further investigation.

WINTER INJURY TO CHERRY BLOSSOM BUDS.

By R. H. ROBERTS, *University of Wisconsin, Madison, Wisconsin.*

While winter injury to cherry blossom buds is common in Wisconsin, it is seldom sufficiently severe to affect seriously the yield of fruit. Because of the severe injury which occurred in the winter of 1915-1916, investigations were begun to determine, if possible, the conditions associated with the occurrence of the killing of the blossoms. Although preliminary observations were made in the spring of 1916, a systematic survey of the situation was not made until the spring of 1917. As the injury was much less common in the spring of 1917, this offered a better opportunity to study the causal factors. The studies were made in the cherry growing section of Door county, near Sturgeon Bay. Less detailed observations in the Bayfield district revealed parallel appearances of the injury in this section.

A summary of the conditions associated with the occurrence of the injury, as determined by these studies, follows:

1. There was a very large number of blossom buds on the trees. Terminal growths of less than six inches had practically no leaf buds.

2. No dying back of the wood was observed. All of the winter injury was confined to the blossom buds.

3. Frequently only one or two of the four or five blossoms within a bud were killed.

4. While the injury observed in 1916 was much more severe than in 1917, it occurred with the same relation with regard to varieties. In that year Richmond buds were very badly injured, especially on the older trees; the older Montmorency trees were badly injured and the young trees of Montmorency were the only ones to have a satisfactory crop of fruit. In 1917 old Richmond trees were the only ones showing serious injury. Old Montmorency and young Richmond trees were slightly injured and young Montmorency trees were very free from injury.

5. The amount of injury bore little to no apparent relation to exposure.

6. Trees which had been partially defoliated by shot-hole fungus the previous season had less bud injury than trees which had normal foliage.

7. Young trees and so-called "shot-hole" trees were later in blossoming in the spring than other trees of the same variety.

8. When the injury was prevalent as on old Richmond trees, the shortest and longest spurs showed less injury than spurs of medium length.

9. Along the terminal growth the injury to the lateral buds was much more noticeable through the central part of the growth than at the base and the tip.

10. The larger buds were most injured.

11. The end lateral bud, that is, the one nearest the terminal bud, showed less injury than the lower buds.

Detailed observations were made to determine the correctness of the conclusions resulting from the field studies. An examination of a thousand buds on an average Richmond tree 16 to 18 years of age, showed the positive relation between the amount of growth made by the tree and the injury resulting to its buds: On the lower portion of the tree the terminal growth averaged 2.79 inches in length; 55.4 per cent of the buds on this wood were dead and the living buds produced 1.88 blossoms per bud. In the top of the same tree 54.84 per cent of the terminals were less than six inches long and averaged 3.87 inches in length; 21 per cent of buds on these limbs were dead and the remainder produced an average of 2.39 blossoms per cluster. Thus 100 buds on the lower part of the tree would produce 83.84 blossoms, while 100 buds from the growths shorter than six inches in the top of the tree would develop 188.81 blossoms. As there was much less injury on the growths longer than six inches than on those which were shorter than this, it is apparent that the injury was approximately three times more common on the lower limbs than on the higher parts of the tree, where the growth was greater.

When injury occurred on the young trees it was also more severe where less growth was made. A tree which made little growth was compared with a normal young tree, 500 buds being examined on each. The terminals of the former averaging 4.54 inches long, 48 per cent of the buds were dead and the remaining buds averaged 1.96 blossoms each. On the other tree the terminals averaged 10.18 inches long, but 7 per cent of the buds on this wood were dead and the remainder averaged 3.66 blossoms each. Thus the tree making the smaller amount of growth developed 101.96 blossoms for each 100 buds, while the tree which made a greater growth produced 340.38 blossoms for each 100 buds.

Immaturity of the tree growth has been considered, frequently, as the cause of winter injury. It is apparent from the above fact that immaturity, or at least late maturity of the wood growth, was not the cause of the injury to the buds as commonly occurring in Wisconsin. In fact, the injury became less severe as the amount of shoot growth, and the consequent lateness of maturity of the growth, increased. The amount of growth made by the trees was doubtless the reason why young and old trees of a variety, were in different classes as regards susceptibility to injury.

Measurements of the length of the spurs verified the observation "that the buds were more injured on the spurs of medium length." The length of the spurs and the corresponding injury was 4 to 6 mm, 8 per cent; 6 to 10 mm, 35.71 per cent; 10 to 100 mm, 75 per cent; 200 to 300 mm, 32.13 per cent; 300 to 350 mm, no injury.

By measuring the buds while they were still dormant it was found that the larger buds were more frequently injured. The average sizes of 300 buds from growths showing various amounts of injury were as follows:

Injury, 21.43 per cent. Width, 2.07 mm. Length, 2.98 mm.

Injury, 54.14 per cent. Width, 2.23 mm. Length, 3.35 mm.

Injury, 79.22 per cent. Width, 2.48 mm. Length, 3.76 mm.

The fact that the larger buds showed the most injury would appear to verify the conclusion arrived at through the observations made in 1916. This opinion was that the injury bears a definite relation to the degree of development which the buds had attained at the beginning of the winter period.

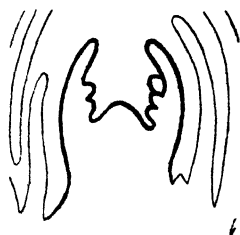
The killing of the buds is not due to any so-called second growth following unusually high winter temperatures, as has been reported as being the cause of the killing of peach buds. The type of injury common in Wisconsin occurs early in the season, usually before New Year's. Dissection

I. BUD DEVELOPMENT.

SEPT. 15, 1917.



SHOT HOLE



YOUNG RICHMOND



OLD MONTMORENCY



OLD RICHMOND

The camera outlines represent the average maximum development of buds from spurs one-quarter inch in length.

It is seen that the degree of development of the buds is directly proportional to the susceptibility to injury. The "shot hole" trees are very free from injury; young Richmond and old Montmorency trees are relatively free from injury and old Richmond trees are very susceptible to injury.

and examination of the buds showed that injury has already taken place this season following a temperature of minus 12 degrees F. during the second week of December. The temperature this winter, as is usually the condition, was constantly below the freezing point from the time the first low temperatures were reached until the injury was apparent.

In order to ascertain if there was a relation between the amount of development of the buds and the occurrence of the injury, samples of buds were collected from different locations in the tree, different aged trees and different varieties of trees at intervals throughout the growing season of this year. The results obtained from sectioning approximately 400 buds are shown in the accompanying charts.

The development of the buds from spurs one-quarter inch in length is indicated by the camera lucida drawings of (Chart 1. These outlines represent the bud development on September 15. Examination of material collected December 1, 1917, indicated that the buds had the same rela-

II. INJURY vs. DEVELOPMENT.



Winter killing of the blossom buds is more severe through the central portion of the terminal growth, as indicated by the undeveloped buds of the shoot diagrammed at the left.

The degree of development of the buds is greater in this same region, suggesting a relation between the injury and the differentiation. (Camera lucida outlines at right.)

The buds as shown in acropetal succession are larger where the injury is greater.

It is suggested that the leaf size may be of prime importance in determining the development of the buds. The outlines show that the leaves are larger where the larger buds and greater development occur.

tive development on this latter date. As shown by the chart, the buds from trees which were partially defoliated by shot-hole fungus were less developed than the buds from old Montmorency and young Richmond trees. These show about equal development. The buds from old Richmond trees are markedly more developed than any other buds. It is seen, then, that the relative degree of development of the buds is shown to be in direct relation to the susceptibility to injury of the different trees.

Chart II shows the occurrence of injury, the relative size of the buds, the size of the leaves and the relative bud development on the terminal growths of old Richmond trees. The shoot shown is an average of the growths of four to five inches in length. It is apparent that the injury is most prevalent through the central section of the growth. The buds at the end are very free from injury, the tip bud being specially so. On wood having 55.4 per cent of dead buds only 8 per cent of the so-called end buds were dead. The living end buds averaged 3.02 blossoms each, while living buds of the other class averaged but 1.51 blossoms per bud.

It may be noted that the size of the buds is in proportion to the occurrence of the injury. The point of greatest interest is, however, that the relative development of the buds is greatest where the injury has been observed to occur the last two seasons.

The range of development within the buds is also very noticeable and, on the basis of the theory that the advancement of the blossom is directly related to the injury, helps to explain why individual blossoms within the bud are killed and others are uninjured.

The reason for the variation in development of the buds on the new shoots may, perhaps, be accounted for as follows: A period of four or five weeks is required for the new shoots to attain a growth in length of four to five inches. This might partially explain why the buds near the tip of the growth are less developed than the buds through the central portion of the shoot as they would be later in forming. Some other reason must be found to explain the case of the basal buds as the degree of development of these buds is opposite to the period of formation.

The size of the leaf subtending the bud is suggested as being a factor of prime importance in influencing the development of the bud. This is indicated by the lesser degree of development of buds on defoliated trees. In this connection, what might be termed the localized influence of the leaf upon bud development was clearly demonstrated by an experiment which was performed upon some American plum trees. Alternate leaves were removed from the long terminal growths of young trees. Removal of these leaves resulted in an arrested development of the accessory blossom buds. No blossom buds formed when the leaves were removed, which left blossom buds only at every other axillary bud where the leaves were undisturbed.

The buds having the least amount of development were found on shoots or spurs which had been partly defoliated by shot-hole fungus and on very strongly growing shoots. In this connection Kraus's theory of growth, as stated in unpublished manuscript, would furnish an interesting explanation of how equal bud development might result from what is apparently opposite conditions of vigor. The theory is that normal functioning, as evidenced by blossom bud formation, is dependent upon the

balance between the unelaborated substances and the assimilated products of the plant. As these vary from normal there is a corresponding deviation from normal growth. Also that the amount of growth is largely dependent upon the nitrates present while the condition of growth, as regards blossom bud formation, is dependent upon the relative amounts of carbohydrates present. To apply the theory to our problem, in the case of the young trees which have made a heavy wood growth the carbohydrates were utilized in the formation of tissue with a consequent arrested development of the blossom buds. With older trees which make less wood growth more bud development follows. In the instance of the partially defoliated trees carbohydrate formation was doubtless below normal and less differentiation was the result. The same condition might also exist with regard to the smaller leaves at the base and tip of the growth where less bud development was found.

Studies have not been made to determine why the hardiness of the buds is affected by their degree of development. It has been suggested that the mechanical spreading of the bud scales by the developing blossoms may be the determining factor. In opposition to this view is the fact that some of the individual blossoms within the bud may be injured while others develop normally. Such injury, apparently, has no relation to exposure and climatic conditions, which suggests that the determining factor would be the condition of the individual blossoms of each bud.

The amount of the injury is in relation to the degree of development of the blossom buds, which, in turn, is usually in proportion to the amount of growth which the tree is making. However, it will not be possible to entirely prevent the injury through increasing the growth of the trees as the injury is primarily due to climatic conditions.

These preliminary observations are given at this time because of their bearing upon the cultural methods practiced in localities where injury is likely to occur, and because of the possible value which they may have in dealing with bud injury of fruit trees of similar fruiting habits, as the sweet cherry, plum and peach.

FEDERAL POINT OF VIEW OF DEMONSTRATION WORK IN HORTICULTURE AND POMOLOGY.

By C. P. CLOSE, *United States Department of Agriculture, Washington, D. C.*

INTRODUCTION.

Usually the term horticulture includes pomology, but as used in the United States Department of Agriculture, horticulture includes the vegetables and ornamentals, and pomology includes the fruits. The speaker does not favor this usage but accepts it for the purpose of this address.

EMERGENCY EFFORT.

For the present the slogan of this demonstration work is "do that which is most important to help win the war," even if it does not entirely harmonize with departmental policy under normal conditions. This is meant, of course, to keep within the legal limits in the expenditure of public funds. Emergency effort should not violate good practice as regards crop rotation, soil fertility, etc., but a well-balanced program should be maintained. Even though the war may not last more than two or three years we must not only plan to support ourselves during that time, but also for the years following.

WHAT IS DEMONSTRATION WORK.

Demonstration work is the distribution of information through the actual doing rather than talking about knowledge gained at an experiment station, on a farm, in a garden, or wherever agricultural truth may be tested out and proven. Demonstration begins where experimentation ends and carries it to the orchard, garden, farm, extension school, or wherever it may be made useful. Good agricultural practice conducted by farmers, truckers and orchardists on their own farms is high grade demonstration work.

LINE OF DEMONSTRATION WORK.

The lines of demonstration work should center on the few things most needed, but are limited only by experiments completed and methods devised and proven sound. They may deal with commercial or home orchards, gardens, truck crops, ornamental plantings, etc. In young orchards they include the preparation of soil, digging and dynamiting holes, pruning and planting trees, cultivating, intercropping, spraying if necessary, and cover cropping. In older orchards they may cover pruning, spraying, cultivating, cover cropping, picking, grading and packing fruit. Fertilizing is doubtful, but is being done. The uses of fruit in making fruit butters, jams, jellies, preserves, fruit juices, vinegar, etc., and for canning and drying, are most important lines for demonstration effort.

In vegetable work they may include the use of hotbeds, coldframes, seed-bed sanitation to produce healthy plants, production of healthy sweet potato plants, selection of healthy seed potatoes, growing special crops on special soils, disease and insect control, gathering, grading, packing and storing, and also canning, drying, pickling, etc.

The work with ornamentals may cover the selection and use of various kinds and types of plants in community demonstrations, on farms, on public properties generally and at educational and other institutions.

There are also the exhibit and lecture features carried out at state, county and community fairs, and by means of single lectures and extension schools.

SOURCE OF DEMONSTRATION INFORMATION.

There is no limitation as to where the information may be secured. It may come from the state experiment station or any other experiment

station or from any source whatever, public or private, farm or garden, so long as it is sound and applicable.

SUBJECT MATTER SPECIALIST AND SUBJECT MATTER RESPONSIBILITY.

The subject matter specialist is the man trained in the line of work he is to demonstrate. He should be thoroughly informed on all phases of his subject both in theory and in practice. Skill, tact, good judgment and resourcefulness are required of him. Responsibility for subject matter usually rests with the department at the college or station with which the specialist is connected.

RELATION OF SUBJECT MATTER SPECIALIST TO COUNTY AGENT.

In a county where there is a county agent the specialist should plan demonstrations with him and reach the county through him. They may jointly select the place of demonstration and the county agent should advertise the date and nature of demonstration and get out the crowd. The county agent project should provide for the help of the various specialists, and he should be free to call upon a specialist for help at any time. It may not be possible, however, for the specialist to respond to every call. In counties having no agent the specialist must necessarily work with individuals or associations direct.

RELATION OF FEDERAL AND STATE COOPERATIVE PROJECTS.

Projects are drawn up in the regular approved form and should state the definite lines of work to be demonstrated, which must be mutually acceptable to all parties concerned. Plans are jointly agreed upon and the administration of the work is delegated to the State Extension Director in accordance with the memorandum of understanding entered into between the Federal Government and the State.

RELATION OF FEDERAL SPECIALIST TO STATE SPECIALISTS AND STATE PROJECTS.

The federal specialist will visit the state specialists and discuss lines of work, equipment, methods of procedure, follow-up work, results and any other points bearing on the projects; he will co-operate with the state specialist in every possible way to build up strong lines of productive work. He will go with the state specialists and county agents to witness demonstrations in orchards, gardens, truck crops, ornamental plantings, etc., and will visit extension schools to study methods of teaching, and the charts, pictures, lantern slides and other illustrative material used. He will keep the state informed of the help which is available in his department in Washington, and will keep his department informed as to needs of the state for help.

DEMONSTRATION PROCEDURE.

The county agents should advertise demonstrations and get out as large crowds as possible. All equipment should be on hand and in good

condition so no time will be lost on repairs or in the use of substitute tools or in making apologies. The interest of the crowd should be held to the points being demonstrated; outside distractions should be avoided as much as possible.

The specialist or whoever is conducting the demonstration should explain each operation as he proceeds. If it is a pruning demonstration he should not only work as he talks, but also have volunteers from the crowd saw off limbs as he directs and thus learn by doing. He should pick out the men who show skill in any line of work, as, for instance, pruning, and train them for future work in the community. This should be done in as many lines as possible so as to have well trained workers throughout the counties.

Demonstrations should be conducted at the same place until something has really been demonstrated. Follow-up work is as essential to success as is the initial demonstration. Orchard demonstrations particularly should be held from three to five years in the same orchard and with the same trees. The condition and treatment of the trees any one year differ from that of any other year and the whole series is really necessary to teach a real lesson. It would be well were most projects planned to run from three to five or more years and be secured by contracts stating clearly the obligations of all parties interested. The contract plan is in effect in several states and is to be commended.

Demonstrations should be located along main lines of travel when practicable, and should always be easily accessible to interested people. A demonstration orchard or plat is quasi-public property as far as learning lessons from it and visiting it are concerned. The man upon whose place the demonstration is conducted should become the center of information for his neighborhood. The final success of any demonstration is the extent to which the principle or practice presented actually becomes the habit of the individual or community.

WEAKNESS OF SOME DEMONSTRATION WORK.

One principal weakness is that some of the demonstration work is scattered over too many minor subjects with no follow-up effort. One visit often begins, conducts and ends a project, then it is history, or junk. Some projects are not well planned, they are hit and miss and short and fleeting. They are in one place one year and in another the next, and do not drive home the lessons they are supposed to teach.

A very important weakness in the work at present and one not easily remedied, is the frequent change of specialists. Each change tends to interrupt the work and time and results are lost. Perhaps some time the specialists will fit so successfully and satisfactorily into their positions that outside offers will not tempt them to change except rarely.

SOME GOOD LINES OF WORK UNDER WAY.

Some of the good lines of work under way are the pruning, spraying, cultivating and cover cropping of farm and commercial orchards; renovating run down orchards; thinning fruit; grading and packing apples

and peaches either with individuals or communities; top working fruit trees; growing vegetable seed; producing disease-free vegetable plants; control of diseases and insects of vegetables; seed potato selection, production and treatment for disease; potato culture; the laying out and improving of home grounds and school and other public grounds and the demonstrating of proper varieties of flowers, shrubs, trees, etc., for this purpose. This is not intended to be a complete list of all the good demonstration work in progress, but covers the range of projects pretty well.

CONCLUSION.

The demonstration movement has developed so rapidly that it may take us some time yet to find ourselves and to know just where we are at. Although at present there is a great mass of tested facts and methods at hand for effective demonstration distribution, yet we feel that we will soon be treading upon the heels of our research men, and it behooves them to push their discoveries into the mysteries of plant life and furnish us abundant material for future use.

FRIDAY, DECEMBER 28, 2:00 P. M.

FACTORS NECESSARY FOR SUCCESSFUL EXTENSION WORK IN POMOLOGY.

By R. W. REES, *Cornell University, Ithaca, N. Y.*

There seems to be no very clear conception of just what constitutes success of extension work in pomology, and how this success is to be measured. Too frequently it is rated by the number of lectures or demonstrations given, the number of letters written, and the amount of printed material sent out on the mailing list. I think we will all agree that while it is desirable to reach a large number of people, the number reached does not measure the value of the undertaking or its true success. Perhaps a real measure would be the number of growers who adopt successfully the recommendations of the extension specialist. To secure an accurate count of such men would be very expensive in time and money, and it would be impossible to measure the degree of their improvement. While we grant the success attained in following recommendations to be a good measure of success, we do not believe it to be a practical measure in checking up the results of a general project.

As a state leader of extension work in pomology, I feel that less emphasis should be placed on the number of people actually reached, and greater emphasis placed on the fundamental principles of sound extension work.

It is evident that the success of extension work will depend upon determining the real problems of pomology in the state, the soundness of principle on which the work is conducted, and the efficiency in presenting

subject matter to the people. There are five factors which contribute largely to the success of extension teaching. They are: relationships within the department; relationships with organizations throughout the state; drawing the project or properly planning the year's campaign; preparation of subject matter material; and execution of the work.

In most of our institutions each department is divided into three sections; research, resident teaching, and extension teaching. These three sections are of necessity more or less interdependent. Extension is particularly dependent upon research work. Its great function is teaching known facts to the people of the state, and if these facts are not supplied it fails. Most cordial relationships must exist between the extension and research specialists if we are to reach the greatest success in extension work.

In most colleges all members of the department do more or less extension teaching in the form of special lectures or occasional demonstrations. Such being the case, it is important that there be a close understanding between all men of the department and a unity of ideas regarding subject matter. Extension work may be rendered almost valueless in a given section by two men from the same department advocating widely different practices or methods in orchard work. Unity of teaching can be secured by frequent informal conferences to consider subject matter and departmental recommendations regarding it.

Organizations throughout the state are increasing in number and strength. Many of these may be used to strengthen and to further extension work. Without doubt by far the most important and effective organization is the Farm Bureau. In all counties where considerable extension work will be conducted it is important to keep in close personal touch with conditions by frequent conferences with the farm bureau manager. Such visits are not only important for securing information concerning local conditions, but also in building and maintaining cordial relationships. In working with the Farm Bureau it is important for the extension leader in pomology to have an opportunity to look over all county projects relating to fruit growing. I have found a number of cases in New York State where we have been able to materially strengthen county projects and make them harmonize with our general state project.

A definite understanding of relationship with the State Department of Agriculture is very desirable. Such a department may in many cases be very helpful both in securing and in disseminating information. If proper relationships exist with such organizations as fruit growers' associations, horticultural societies, the grange and other associations, they may frequently be of great service in carrying out state or district campaigns.

Previous to the passage of the Smith-Lever Act most extension work was very poorly planned. Perhaps there were a few phases of the work more or less clearly outlined, but the general tendency was to simply take care of the miscellaneous requests for lectures and demonstrations. No doubt some good came from this scattering type of work, but much time was lost and effectiveness weakened by lack of concentration.

All work conducted with Smith-Lever money must be in project form and all other work should be. Preparing the project is a matter

which requires a knowledge of the problems confronting the growers in the state, a careful weighing of these problems as well as a careful weighing of what you have to offer. The project should be drawn by the extension specialist after consultation with the extension director. After being drawn it should be considered in detail and necessary revisions made at a conference of all members of the department. It should be broad enough to meet unexpected emergencies, yet concise and definite, giving an outline of the work which will actually be conducted.

While it will always be necessary to meet a greater or lesser number of miscellaneous requests for work of a general character, they should be kept to the minimum. Greater effectiveness will be secured if the work is planned in the form of campaigns, of county, district or statewide character. Such operations as pruning, spraying for the control of certain pests, certain types of orchard soil management, thinning apples or peaches, and the establishment of central packing houses, are good subjects for county or district campaigns. By carefully planning the season's work and maintaining proper relations with agencies in the field, several of these campaigns can be conducted each year.

The preparation of subject matter for extension teaching is very important. In almost every state demands on extension workers have been far too heavy for the good of the work. The schedule on the road has been such that adequate preparation is out of the question. A certain amount of reading or writing can be done on the train or in the hotel, but on the average crowded train or in the uninviting small country hotel, the atmosphere is not conducive to keen thinking and careful preparation. I believe the average man will do more real effective work in a year if at least half his time is spent in preparation.

In conducting a campaign it is necessary to prepare articles for farm bureau and county newspapers. Such articles must be well prepared. They must meet the local situation, must be concise and be written in readable style. Time must be given to their preparation.

Reading course circulars and bulletins of the popular type published by extension departments need particularly careful preparing and editing. When sent out on request they go to persons who really desire information and will carry out instructions just as stated, therefore the need of greatest care in statement of subject matter. Such publications reach a different class of people than do research bulletins. The majority of persons who read research bulletins consider them as the work of the author and not the institution. The credit or discredit goes to the author. The majority of people who read extension circulars do not consider the author, but hold the college responsible for the recommendations.

Few phases of extension work require more time in preparation than exhibits. The one in charge of preparing the exhibit must know by what class of people it will be most largely visited. If most visitors are fruit growers, he must know what kinds of fruit they grow, and what features of production will be of the greatest value to them. If the exhibit will be most largely visited by people of the city, educational features for the benefit of consumers should be given the leading place. To be worth while the whole exhibit must be plain and simple, yet alive and attract-

ive. Without neglecting the artistic it must be plainly educational and of such a nature that it will at a glance drive home one or two points. So much time and expense are required in preparing pomology exhibits of educational value that there is grave doubt as to their advisability where they will not receive a very large attendance of the classes it is desired to reach.

Extension lectures, whether given as single lectures or given in series at demonstration schools, have suffered from poor preparation. The extension instructor does not have time to conduct experimental or research work, but he must have time to study and keep informed on the latest work covering a wide range of subject matter. He must also have time to work this material up in a clear, logical, concise manner. Even in an up-to-date community of fruit specialists, it is very easy to impress them with a talk which does not add one word to their knowledge or even make them think. All that is necessary is to agree with present practices and do it in an attractive way. Such a talk is plainly a waste of time. If we do not get down to some real fundamental facts and give people something to think about, we had better stay at home. Every time an afternoon lecture or demonstration is attended by 50 men the community has theoretically lost one month of working time for one man. It is important to leave something to compensate for this time.

In the actual execution of extension work the two big problems before the extension leaders are to keep his program of work up to a time schedule and to perform a maximum amount of work with a given amount of finance and assistance. Pruning demonstrations late in the spring after the bulk of pruning has been done, are for the most part a waste of time. They had much better be given in the late fall and early winter when men who attend them will still have a chance to utilize any points they may gain. Likewise, demonstrations in grading and packing should be given with late summer and early fall varieties before the picking season opens up for winter sorts. The subject matter taught by lecture or demonstration should be slightly in advance of the season when it is to be used.

The importance of a carefully planned itinerary which will give a maximum number of lectures, demonstrations, conferences or orchard visits, in a limited time and with the least amount of travel, cannot be over-emphasized. Preparation can best be done at home. When on the road all available time should be spent in actually doing extension work.

The proper utilization of individuals and agencies in the field will greatly increase the amount of work which may be conducted in a given period. In every state there are a number of growers who are able and willing to give a few lectures or demonstrations. It is seldom advisable to use these men in their own communities, but they can be used with the greatest success in nearby neighborhoods where their reputations are known. Last year in New York State more than a hundred such lectures and demonstrations were given that would have been impossible with our own force.

Farm bureau managers who have had horticultural training can be of the greatest assistance in the carrying out of project work. In one day

last year I visited ten peach orchards with a county agent. At each orchard we arranged for thinning demonstrations. Later, in company with the agent, I gave two demonstrations and he gave the remaining eight. At each of these orchards the owners thinned fruit on practically the entire orchard, but left blocks of commercial size as checks. The agent arranged for cost accounts to be kept on thinned and unthinned blocks and also for records of yields and grades of fruit as harvested.

In another county in company with the county agent, twenty-seven orchards were visited in three days and plots selected for test demonstrations of cover crops. The county agent finished the work by seeing that the crops were actually sown at the proper time and the results checked at the end of the growing season.

In other leading fruit counties a considerable amount of similar work has been conducted. The agent could not well do this work alone and it would have been out of the question for us to even attempt it without his co-operation.

In summing up the factors which contribute to success of extension work in pomology we would emphasize the following: A cordial relationship and mutual understanding must exist within the department; a spirit of co-operation and clear understanding must be established and maintained with organizations throughout the state; a clear-cut plan of work giving consideration to the various fruit-growing sections of the state and differentiating between the important and non-important problems in each section; a reserving of plenty of time for office work and for the careful preparation of all subject-matter material; a careful timing of all project work and a utilizing of all agencies to increase the scope and usefulness of the work.

THE ROLE OF SOIL TEMPERATURE IN TREE GROWTH.

By JOSEPH OSKAMP, *Purdue Experiment Station, Lafayette, Indiana.*

The temperature of the soil as a factor in tree growth is one of the phases of an orchard soil management investigation being conducted by the horticultural department of Purdue University. As a long-time experiment, covering at least 15 years, it was thought highly desirable to know the temperatures obtaining in the soil under the different systems of management, and the relation of these temperatures to tree growth and certain factors of tree environment.

I have been asked by the program committee to dwell particularly upon the methods employed in the study of soil temperature, so I will give something of the early difficulties which beset this phase of the investigation.

The best method to follow in securing the temperature of the soil was, of course, the first problem to present itself. Whatever method was employed it was essential that it should give a fairly definite knowledge of the soil temperature during each 24 hours and that it should be not too complicated or expensive, but yet accurate.

In the earliest work ordinary centigrade thermometers were used of the type common in chemical laboratories. These thermometers were inserted in hollow glass cylinders (slightly shorter than the thermometers) with corks at each end through which the thermometers could be projected. A hole was made in the soil by means of an auger and the glass cylinder placed therein. The thermometer was now pushed down through the corks so that the bulb directly penetrated the earth at the desired depth. The glass cylinder was supposed to insulate the thermometer and make it possible, by drawing the thermometer bulb up into the cylinder, to read the soil temperature before the thermometer was influenced by the temperature of the air. The readings were made three times daily.

The above arrangement was open to many objections, the more important of which were learned later, but at the time the greatest objection was the impossibility of reading the thermometer quick enough to get an accurate record. The difficulty was due to the condensation of moisture in the cylinder and on the thermometer, thus obstructing an immediate reading.

Frankiel soil thermometers were then employed, which overcame this difficulty. These thermometers have a long stem so that the temperature scale is above ground. The thermometers are encased in iron tubes about the size of ordinary water pipe, and have a soil auger on the end, thus providing for penetrating the soil. The lower end of the case immediately adjacent to the mercury bulb has numerous perforations. The soil which comes in contact with the thermometer bulb must, therefore, be such as has found its way through these perforations, as the instrument was bored into the soil. At the perforations this soil comes in contact with the exterior soil and this is the only direct connection between the thermometer bulb and the soil of which the temperature is required. There was a feeling that the sudden changes in temperature which were unavoidable in the exposed iron case above the ground, must be conducted below, and thereby affect the thin layer of soil surrounding the thermometer bulb. Such a feeling was confirmed by exposing the iron case of one Frankiel soil thermometer to the direct rays of the sun, while another setting beside it in the same soil was shaded. The one exposed to the sun developed a higher temperature.

The soil temperature records were so far considered a failure. Not only were the temperatures taken in this manner surrounded with many inaccuracies, but the true temperature range was not obtained at all. The use of any ordinary type of thermometer for soil work which requires an observer to make the records is open to grave objections in an investigation which has to do with the response of a plant to its environment. This was brought out by taking the temperature every hour during the day and night for several days. It was found that a great difference existed between the arbitrary readings and the actual minimum and maximum temperatures which occurred.

The really pertinent soil temperature relations from the standpoint of the tree are the actual maximum and minimum which occur daily. The average or mean temperature or even two or three daily readings for that matter, are of little concern in a study of this kind. For instance, one cultural system may show an actual minimum of thirty and a maxi-

imum of seventy, while another might show forty and sixty, respectively, and yet they would both have a mean of fifty. The critical condition for the tree is the extremes of temperature to which it is subjected. It is these extremes which will limit the protoplasmic activity of the tree as well as those biochemic activities going on in the soil. The ameliorating effect which might be the result of differences in soil management practices would also not be shown in its full significance unless the fluctuations of the day were known.

It being firmly believed by this time that self-recording instruments must be installed if trustworthy results were to be obtained, soil thermographs were purchased. Upon installing these instruments it was not surprising to find that the Frankiel soil thermometers, during hot summer weather, reached a maximum six hours too early and registered a temperature four degrees too high. It was found further that during the season of greatest daily range, that is, during the summer months, the maximum temperature of the soil occurred about 10 P. M. and the minimum temperature some 12 hours later. This was at a depth of nine inches.

The soil thermographs used were of the pattern manufactured by Julien P. Friez & Sons, Baltimore, Maryland. The instruments consist of a wafer disk filled with ether or some other sensitive liquid. This disk is connected on one end through a hollow wire to a thermometer bulb planted in the soil and on the other end by a system of levers to a pen. In a suitable position for the pen to trace upon is a cylinder or drum, revolved by an eight-day clock. Forms on which are printed the time of day and the degrees of temperature are fastened about these drums and the pen traces the temperature thereon, continuously. The bulb which is buried in the soil is a hollow copper tube about one and one-fourth inches in diameter and some ten inches long.

The bulb of the thermograph was so planted in the soil that on mulched plots it was beneath the mulch collar about a foot from its outer edge, and on other plots an equivalent distance from the tree, this distance being about six feet. The bulbs were planted northeast of the trees at a depth of nine inches. This exposure was preferred because more uniform conditions could be obtained on all plots by such location. The depth was chosen after a consideration of the depth of plowing, of the biochemical activities occurring in the soil, the depth of rooting of the trees, etc.

The thermometer bulbs were planted with as little disturbance of the soil as possible. A rectangular hole of sufficient size was dug and in one side of this excavation a gallery was made just large enough to receive the bulb. The bulb was therefore surrounded on three-fourths of its surface by soil which was undisturbed and of original compactness and physical condition.

All instruments were carefully checked with a standard thermometer at the beginning and during the course of the experiment, and their behavior was quite satisfactory. The placing of new chart sheets on the drum each week was done with care and precision, so that each blank fit simply and in exactly the proper position. As the drum and pen arm are set correctly in their relative positions to each other, it

can be readily imagined that a slight discrepancy in placing the chart sheets would make an error in the temperature records.

The temperature data have been procured under field conditions such as exist in many Southern Indiana apple orchards. The location in question is in Southeastern Indiana on an upland soil, composed of a very high percentage of silt and clay. The records here considered were taken while the trees were yet in their pre-bearing or vegetative period. Various other details surrounding the general investigation of orchard soil management methods have been published in Purdue University Agricultural Experiment Station Bulletin No. 205. The temperature records cover a period of four years and include five plots.

For the purpose of this paper the four major plots only will be considered and as space is limited the maximum and minimum temperatures by weeks for a two-year period will be presented. The additional data substantiate what is here shown. The reason for reporting the maximum and minimum temperatures instead of averages or means has already been made plain.

The systems of soil management carried out on the four major plots are as follows:

Plot A received clean cultivation during the greater part of the growing season with a rye cover crop sown in late summer and turned under in the spring. The average depth of plowing has been seven inches.

Plot C is in grass, which is cut and allowed to lie where it falls, but a supplementary mulch consisting of a bale of wheat straw was applied to each tree annually. These bales averaged eighty pounds in weight and the straw was scattered well out beneath the spread of branches.

Plot D is in grass, which was cut and allowed to lie where it fell, one to three cuttings being made each season.

Plot F is in grass, which is mowed one to three times during the year and the grass raked up as a mulch collar about the trees. The amount of mulch obtained in this way from the grass was less than half the amount applied in the form of straw to the straw mulch plot.

A study of the soil temperature records under these various treatments shows that clean cultivation with cover crop and straw mulch, holds the extreme temperature positions which have been induced by soil management practices. The clean culture cover crop plot has been the coldest one in winter and the warmest one in summer and has shown the greatest daily range in temperature. The straw mulch has been the warmest one in winter and the coldest one in summer, and has exhibited a very gradual change from summer to winter, with an insignificant daily fluctuation. The grass plot where the grass is cut and mulched shows a temperature trend quite similar to straw mulch, although the effect is less pronounced than that of straw mulch because of the less amount of mulching material applied. The straight grass plot where the grass is cut and falls back upon the ground, gives a temperature condition more variable than grass mulch, but less extreme than tillage. In brief, the temperature range varies inversely with the amount of mulch material covering the soil.

TABLE I.
WEEKLY EXTREMES OF SOIL TEMPERATURE UNDER DIFFERENT
SYSTEMS OF SOIL MANAGEMENT.
1915

Month	Week	Clean culture cover crop		Straw mulch grass cut let lie		Grass cut, let lie		Grass cut piled	
		de-grees F. min.	de-grees F. max.	de-grees F. min.	de-grees F. max.	de-grees F. min.	de-grees F. max.	de-grees F. min.	de-grees F. max.
January	1	32.0	33.5	35.0	37.0	35.0	37.0	34.0	36.0
	2	31.0	32.0	34.0	36.0	32.5	35.0	34.0	36.0
	3	31.0	32.0	35.0	36.0	33.0	34.0	34.0	35.5
	4	32.0	33.0	35.0	36.5	33.5	35.5	35.0	37.0
February	1	33.0	34.0	35.0	36.0	33.0	35.0	34.0	37.0
	2	33.0	36.0	35.0	37.0	33.0	35.0	34.0	35.0
	3	32.0	45.0	35.0	39.0	32.5	38.5	33.5	37.5
	4	35.0	40.0	36.0	38.5	33.0	38.0	34.0	37.0
March	1	35.0	47.0	36.0	40.0	35.0	41.0	36.0	41.0
	2	34.0	37.0	36.0	37.0	33.0	35.0	35.0	37.0
	3	35.0	41.5	36.0	37.0	33.5	36.5	35.0	37.0
	4	36.0	40.0	37.0	38.0	35.0	37.0	35.5	38.0
	5	35.0	41.0	36.5	38.0	35.0	38.0	36.0	38.5
April	1	35.0	42.0	35.0	37.0	34.0	38.0	35.5	38.0
	2	40.0	52.5	38.0	45.0	37.0	47.5	37.0	47.0
	3	44.0	55.0	42.0	45.0	42.5	48.0	43.0	47.0
	4	50.0	66.0	45.0	53.0	46.0	58.0	45.0	56.0
May	1	57.0	67.0	52.0	55.0	53.0	59.0	52.5	57.5
	2	50.0	64.0	51.5	54.0	52.0	57.0	52.5	55.5
	3	50.0	65.5	51.0	56.0	52.0	60.0	52.0	58.0
	4	54.0	63.0	51.5	55.0	52.0	58.0	52.0	57.0
	5	55.5	63.5	55.0	56.0	55.0	59.0	55.0	59.0
June	1	58.0	68.5	56.0	59.0	57.0	62.5	57.0	62.0
	2	60.0	71.0	57.0	60.0	58.5	65.5	58.5	64.0
	3	63.0	70.5	60.0	62.0	62.0	65.5	61.5	65.0
	4	62.0	72.0	60.0	62.5	62.0	66.0	61.0	65.0
July	1	62.0	74.0	62.0	64.0	62.0	66.0	63.0	64.5
	2	61.0	71.0	61.0	64.0	61.5	66.5	61.0	65.0
	3	68.0	80.0	64.0	67.5	66.0	71.0	64.5	69.5
	4	67.0	77.0	64.0	67.5	64.5	71.0	65.0	70.0
August	1	71.0	80.0	65.0	69.0	66.0	71.0	66.0	71.0
	2	64.0	79.0	65.0	69.0	65.0	71.0	65.5	71.0
	3	65.5	75.0	65.0	66.0	65.0	68.0	66.0	68.0
	4	61.0	76.5	64.0	66.5	63.0	68.0	64.0	68.0
	5	62.0	71.0	62.0	64.5	62.0	65.0	63.0	66.0
September	1	57.0	70.0	60.0	63.0	58.5	63.5	60.0	64.0
	2	62.0	75.0	63.0	66.5	61.5	67.0	63.0	67.5
	3	68.0	76.0	66.0	67.0	66.0	68.0	67.0	68.5
	4	56.0	70.0	61.0	67.0	57.0	66.0	60.0	68.0
October	1	54.5	63.0	59.0	62.0	56.5	61.0	58.5	63.0
	2	45.5	65.0	53.0	61.0	49.5	60.5	52.5	62.0
	3	47.0	62.0	54.0	58.0	50.0	57.0	53.0	59.0
	4	50.5	61.0	55.0	59.0	52.0	58.0	54.5	59.0
November	1	47.0	54.5	53.0	56.0	48.0	53.0	52.0	56.0
	2	46.0	55.0	52.0	55.0	47.0	51.5	50.5	55.0
	3	42.5	55.5	50.0	54.0	46.0	52.0	50.0	54.5
	4	38.0	43.5	45.0	50.0	41.5	46.5	45.0	50.0
	5	38.0	48.0	45.0	47.5	40.0	45.0	43.0	47.0
December	1	35.0	39.0	41.0	46.0	37.0	43.0	40.5	46.0
	2	34.5	35.0	40.0	41.5	36.0	38.0	39.0	41.0
	3	32.5	34.5	38.0	40.5	34.0	37.0	36.0	40.0
	4	32.5	33.5	38.0	39.0	34.0	35.5	36.0	38.5

TABLE I.
WEEKLY EXTREMES OF SOIL TEMPERATURE UNDER DIFFERENT
SYSTEMS OF SOIL MANAGEMENT.
1916

Month	Week	Clean culture cover crop		Straw mulch grass cut let lie		Grass cut, let lie		Grass cut piled	
		de- grees F. min.	de- grees F. max.	de- grees F. min.	de- grees F. max.	de- grees F. min.	de- grees F. max.	de- grees F. min.	de- grees F. max.
January	1	33.0	43.5	38.0	41.0	35.0	41.0	37.5	42.0
	2	33.0	41.0	37.0	40.0	34.0	39.0	37.0	41.0
	3	32.0	42.0	36.0	41.0	34.0	40.0	37.0	41.5
	4	28.5	32.5	35.0	36.0	32.0	35.5		
	5	31.0	47.5	35.5	44.5	32.0	43.0		
February	1	33.0	47.5	36.0	45.0	34.0	43.0	36.0	44.0
	2	32.0	33.5	35.0	36.5	32.0	35.0	35.0	38.0
	3	32.0	33.0	35.0	35.5	32.0	34.5	33.0	36.0
	4	32.5	40.0	35.0	36.5	32.0	34.0	34.0	36.5
March	1	32.0	34.0	35.0	36.0	32.0	34.0	34.0	36.0
	2	31.5	40.5	35.0	38.0	32.0	35.0	34.0	36.0
	3	33.0	45.5	35.0	37.0	32.0	36.0	34.0	37.5
	4	34.0	53.0	35.0	43.0	32.5	45.0	34.0	43.5
April	1	41.0	52.0	41.0	43.0	40.0	44.5	41.0	43.5
	2	35.5	49.0	39.5	43.0	37.0	43.0	39.5	43.5
	3	35.0	57.0	40.0	47.0	36.0	48.0	38.5	47.5
	4	44.0	56.0	46.0	50.0	45.0	50.5	45.0	50.0
May	1	46.5	60.0	46.5	49.0	45.5	50.5	46.0	49.0
	2	49.0	68.0	49.0	53.0	48.0	56.0	49.0	54.0
	3	54.0	67.5	51.5	53.5	53.0	57.0	53.0	55.0
	4	51.0	64.0	51.0	54.0	51.0	58.0	51.0	56.0
	5	58.5	76.5	52.0	57.5	54.0	63.5	53.0	60.0
June	1			57.0	58.0	59.0	62.0	58.0	60.5
	2			57.0	58.5	58.0	62.0	57.0	60.0
	3			57.0	59.0	59.0	62.0	58.0	60.0
	4			58.0	60.0	59.0	64.0	59.0	62.0
July	1			60.0	64.0	62.0	67.0	61.0	65.0
	2			62.0	63.5	63.0	67.5	63.0	65.5
	3								
	4	70.5	78.0	67.0	69.0	68.5	73.0	68.5	72.0
	5	72.0	78.5	67.0	70.0	68.5	73.0	69.0	73.0
August	1	70.5	78.5	68.0	71.0	69.0	73.5	69.0	73.5
	2	67.0	80.0	68.0	71.5	68.0	74.0	69.0	74.0
	3	67.0	77.0	68.0	70.5	67.5	72.0	68.0	71.0
	4	66.0	78.0	66.0	71.0	66.0	72.5	67.0	72.5
September	1	62.5	69.5	64.0	66.0	62.0	67.0	62.5	67.0
	2	63.0	72.0	64.0	68.0	62.5	68.0	63.0	68.5
	3	61.0	71.5	60.0	66.5	59.0	66.5	59.0	67.0
	4	58.0	63.5	58.0	60.5	56.0	61.0	57.0	60.0
October	1	51.0	65.5	56.0	62.0	53.0	61.0	54.0	62.0
	2	51.5	62.0	55.5	60.0	52.0	58.0	53.0	59.0
	3	50.0	62.5	53.0	59.5	51.0	60.0	52.5	61.0
	4	43.0	54.5	49.0	55.5	46.5	55.0	48.0	56.0
	5	44.0	49.0	49.0	50.5			47.0	50.0
November	1	44.5	52.0	48.5	51.0	45.0	50.0	47.0	51.0
	2	44.5	52.5	49.0	52.0	45.0	50.0	47.0	52.5
	3	38.0	47.0	43.0	48.0	38.0	46.5	40.0	49.0
	4	37.0	44.5	41.0	46.0	37.5	43.0	41.0	45.0
December	1	37.0	45.5	41.0	45.0	37.5	44.0	40.0	45.5
	2	39.0	46.5	42.5	46.5	39.0	45.0	41.0	46.5
	3	35.0	40.0	37.0	42.0	35.0	40.0	37.0	43.0
	4	34.0	35.5	36.0	37.0	35.0	37.0	35.5	38.0
	5	33.0	35.0	35.0	37.0	33.5	37.5	34.5	37.0

TABLE II.

AIR TEMPERATURES FOR COMPARISON WITH SOIL TEMPERATURES
TAKEN DURING SAME PERIOD.

Month	Week	min. 1915 degrees	max. 1915 degrees	min. 1916 degrees	max. 1916 degrees
		F.	F.	F.	F.
January	1	2.0	42.0	22.0	62.0
	2	13.0	47.0	12.0	55.0
	3	19.5	54.0	-3.5	68.0
	4	-17.5	36.5	0.5	66.5
	5			32.5	68.0
February	1	-13.0	49.0	2.5	41.5
	2	17.0	48.0	-9.0	56.0
	3	14.0	63.0	2.0	55.0
	4	16.5	58.0	10.5	65.0
March	1	16.0	60.5	5.0	57.5
	2	20.0	48.0	14.5	64.5
	3	18.0	55.0	8.0	66.5
	4	20.0	47.0	21.0	72.5
April	5	16.0	51.0		
	1	16.5	56.0	29.0	68.0
	2	37.0	79.0	23.0	60.0
	3	29.0	74.0	31.5	77.5
	4	49.0	87.0	33.5	80.0
May	1	38.0	86.0	38.0	75.0
	2	31.0	78.5	37.5	84.0
	3	38.0	80.5	46.0	87.0
	4	32.0	80.5	30.0	71.5
	5	43.0	76.5	52.0	88.5
June	1	51.0	81.0	47.0	79.0
	2	40.0	88.0	45.0	78.0
	3	48.0	83.0	51.0	82.0
	4	43.0	87.0	45.0	84.5
	5				
July	1	48.5	87.0	53.0	90.0
	2	46.0	83.5	51.0	91.5
	3	61.5	91.5	63.5	93.0
	4	49.0	88.0	56.0	95.0
	5			63.0	98.5
August	1	60.0	92.0	59.0	94.5
	2	53.5	85.5	45.0	95.0
	3	59.0	82.0	59.5	94.5
	4	47.0	87.0	47.0	94.5
	5	47.5	80.0		
September	1	38.0	81.5	43.0	86.0
	2	61.0	88.0	49.0	93.0
	3	55.0	89.0	29.0	86.5
	4	35.5	81.0	30.0	76.5
	5				
October	1	39.0	79.0	28.0	87.5
	2	23.0	81.0	33.0	38.0
	3	38.0	77.0	27.0	72.5
	4	34.0	76.5	23.0	67.0
	5			27.5	72.0
November	1	29.0	76.0	24.0	74.0
	2	25.5	77.0		
	3	22.5	71.0	6.5	60.5
	4	20.0	56.5	16.0	68.0
	5	23.5	68.0		
December	1	17.0	39.5	18.0	58.0
	2	15.0	45.0	12.0	63.0
	3	6.0	52.0	5.0	42.0
	4	14.5	47.0	3.5	33.0
	5			7.0	54.0

TABLE III.
GROWTH RECORD OF TREES UNDER DIFFERENT SYSTEMS OF SOIL
MANAGEMENT.

Systems of management	Average yearly gain in girth cm.
Clean culture cover crop	5.17
Straw mulch grass cut, let lie.....	5.19
Grass cut, let lie	3.43
Grass cut, piled	3.62

The extent to which cultural practices have influenced soil temperatures has not been great, about ten degrees in the maximum and somewhat less in the minimum. The greatest variations between plots have occurred during the summer months and are comparatively small in late fall and winter. A heavy mulch maintains the temperature of the soil a few degrees warmer in winter and many degrees cooler in summer than clean cultivation with cover crop.

A comparison of the soil temperatures in Table I with the air temperatures in Table II, taken during the same period, will be found interesting. An intimate relation between the temperature of the soil and that of the air is manifest, in fact, we must conclude that the temperature of the soil is largely a reflection of the air temperature. It has not been the purpose to especially investigate the many complex factors influencing soil temperature, but rather to ascertain the extent to which soil temperatures might be changed by cultural practices and the effect of such change upon the apple tree. Emphasis is here given to the dependence of soil temperature upon air temperature for the reason that the principal factor governing soil temperature is one that has limited possibilities of being altered under field conditions by human intervention.

In considering the growth records of the trees appearing in Table III it will be seen that in point of tree growth there is little to choose between cultivation or a heavy mulch. The grass mulch not being what it should have been is but little better than where the grass is cut and let lie where it falls. But between tillage and a heavy mulch on the one hand and grass or grass mulch on the other, there is a striking difference in favor of tillage or a heavy mulch.

The question now is—can the behavior of the trees be directly correlated with the temperature of the soil? The answer is "No." The two plots which have made the most substantial and practically parallel gains in tree growth exhibit the two extreme types of soil temperature phenomena that have been here experienced. The tilled plot having the coldest soil in winter and the warmest soil in summer, with violent daily fluctuations, made an average gain in trunk girth of 5.17 centimeters, while straw mulch having practically the reverse of these conditions, that is, the warmest soil of any plot in winter and the coolest of any plot in summer, with very slight daily change, made a similar gain in tree growth. The grass mulch plot following a temperature trend similar to straw mulch made a yearly girth gain of only 3.62 centimeters. The plot where the grass was cut and allowed to lie made a girth gain of 3.43 centimeters, although it exhibited a temperature near to that of tilled land.

Soil temperature, therefore, seems to play a minor role in the growth of young apple trees, working neither directly for nor against vegetative activity. A cool soil temperature during the growing season of the trees has not been inimical to growth, neither has a slightly lower winter temperature on some plots. Sudden changes in soil temperature, as here experienced, seem to have been followed by practically the same growth results as where a very uniform temperature was maintained.

It may be suspected from the behavior of the trees under observation that the tolerance of the apple tree for variations in soil temperature is great enough to make changes induced by different systems of management of no direct significance. Variations in the range of those induced, however, may in time have an indirect effect through their influence on nitrification or ammonification and other processes connected with the metabolism of soil micro-organisms.

METHODS IN BREEDING PEACHES.

By C. H. CONNORS, *Experiment Station, New Brunswick, N. J.*

For a number of years at the New Jersey Agricultural Experiment Station, attempts had been made to secure a number of peach stones by crossing known parents. The results were practically nil. The method first used was to tie bags made of paper of various weights over the blossoms, but the high winds which prevail at the blooming time destroyed the bags in most cases. Where the bags were left intact, it was found that the permitting of the bag to remain on the necessary length of time resulted in the yellowing of the foliage and the failure of the fruit to develop properly. In later work, sleeves made of mosquito netting were used, but these also proved to have disadvantages.

When the speaker took charge it was decided to establish the breeding work with peaches as a major project. After some consideration the method of protection followed in some apple pollination studies was adopted and, accordingly, tents were constructed to cover the entire tree. These tents were made of 2 by 4 inch lumber for the upright and top cross pieces. Shingle lathes were nailed on the sides and top and the whole covered with cheesecloth, leaving a door for entrance. Six of these were constructed the first year, five being large enough to cover trees that were eight years old, approximately 10 feet in each dimension. These proved to be very satisfactory. They offered absolute protection against the entrance of insects, and, in addition, proved to be somewhat of a protection against the weather for the man who was doing the work of pollination. The emasculating and pollinating could be done with great facility.

The primary part of the work was to study the inheritance of size of blossoms. Of course, peaches are not genetically pure, so that in part we are "going it blind;" but it is a well known fact that certain varieties give seedlings that relatively resemble the parents. It was also thought that the medium-sized blossoms might be hybrids. Since then we have learned that all three types of bloom, large, medium and small, are found growing wild in China.

The varieties chosen for this particular phase were Greensboro, with large blossoms; Belle, with medium blossoms, and Elberta and Early Crawford, with small blossoms. Just before the blossoms opened each tree that was covered was divided as nearly as possible into four equal parts, this depending upon the scaffold branches. Three parts were emasculated to be pollinated with each of the three other varieties, while the fourth part was left to be self-pollinated. The emasculation was performed by means of curved tweezers. At the proper stage, a cut could be made in the side of the corolla below the point of attachment of the stamens, and then by a lifting movement, the corolla and stamens could be torn from the bud. If the buds were immature it was sometimes necessary to use a pair of curved scissors and then tweezers to remove the stamens.

Pollen was taken in small test tubes from the other trees and applied with the finger or a camel's hair brush to the stigmas. In some cases blossoms were removed and the pollen applied directly from the anthers. It was found that fruit set quite as readily on the blossoms left for self-pollination as on the hand-fertilized pistils.

After the fruits had set, the shelters were removed to permit of more convenient cultivation and spraying. The fruits were allowed to mature to almost the point of dropping, when they were removed and the stones taken and dried. These were placed in sand for stratification, and in the spring were opened and planted in nursery rows. It was found that the seeds of the early clingstone varieties would not mature. Early freestones or semi-clings such as Carman and St. John, will give a small percentage from stone to tree, about 10 per cent on the average, while later freestones will give up to 50 per cent.

The following spring the seedlings were dug and planted in orchard form. The trees from the first year's work were interplanted in a young apple orchard, 10 by 10 feet, and the later planting was made 10 by 12 feet. These distances will allow sufficient space for the development of the tree to fruitage age.

A total of 403 trees descended from known parents was planted in the spring of 1916. Some of these will blossom in the spring of 1918. In 1917, 1,073 seedlings from known parents were planted. In addition to the above, there were planted also 248 seedlings from open pollinated blossoms.

A method has yet to be devised to secure the F_1 generation, but this will probably be accomplished in much the same way as the foregoing.

RELATION OF SOIL COMPOSITION TO FERTILIZER RESPONSE IN PENNSYLVANIA.

By J. P. STEWART, *Pennsylvania State College, State College, Pa.*

(This address will form the basis of a bulletin to be published in the near future by the Pennsylvania Experiment Station.)

SATURDAY, DECEMBER 29, 9:30 A.M.

EXPERIMENTS IN HORTICULTURAL TEACHING.

By W. L. HOWARD, *University Farm School, Davis, California.*

The experiments in horticultural teaching which the University of California has tried out or is planning to try out, are four or five in number. The first of these is the summer traveling course in pomology. All university students specializing in pomology are required to take this course between the sophomore and senior years. The class spends six weeks traveling over the state, visiting and studying the different fruit districts and fruit industries. One of the regular instructors accompanies the class or rather there is one instructor for every ten students. By faculty ruling these instructors must now be of professional rank. Formerly the party traveled by train, but latterly by auto and auto-truck. The distance covered has averaged about 1,000 miles. Complete arrangements are made in advance as to hotel accommodations and places to be visited. The owner or manager of the orchard or industry visited shows the party around and the students are encouraged to ask questions. They are supposed to write up their notes every night and are required to hand in weekly reports. The expenses of the teachers are defrayed by the Division of Pomology. Each student pays his own expenses. On the average these amount to about \$125 for the trip.

The advantages of this course are that the men gain quite a lot of first-hand information about the entire fruit business from nursery to marketing agencies. The disadvantages are that the men—particularly those between the sophomore and junior years, asked too many amateurish questions which sometimes left a bad impression, as it has seemed impossible to make our hosts understand that the men do not claim to be anything but "tenderfeet" in the fruit line. Another objection is that the students see only the brighter side of the fruit business, as it is but natural that the better orchards only are visited. Furthermore, it is obvious that free discussion and frank criticism could not be indulged in while looking over a property. And, finally, too many fruit growers—even successful ones, are inclined to ride some hobby, thus giving to inexperienced men many false ideas.

While serving a useful purpose, the course is not an unqualified success and we would like to see it changed considerably. Briefly, we hope to devise some plan whereby the students will actually work for a few days at least, here and there in an orchard or packing house. Our ultimate idea is to have orchards enough of our own to furnish them work for a few or several weeks in the summer.

Another part of the university instruction that is out of the ordinary is that the pomology students in their junior or senior year are required to spend one full semester, January to May, inclusive, working in the university farm orchards. There are no lectures aside from necessary

instructions that have to be given previous to starting to work. The periods are four and one-half hours long. The work covers everything that can be done during the winter and spring. In the main, January is spent in pruning, February in spraying and planting, March in pollinating and fruit thinning, and April and May in fruit thinning, studying cover crops, cultivating and miscellaneous work.

The second experiment is in the farm school, where we are trying out the plan of giving a maximum of instruction in the field and a minimum in the class room. No formal lectures are scheduled, the talking being done either in the field while the work is going on or on rainy days inside. The periods are four hours long. We aim never to have more than ten men in a section. This enables us to give the students close supervision. Since pruning is the most important single cultural operation, we naturally give more time and attention to that than to anything else. This has made the problem of finding enough work to keep the men busy all of the time a rather serious one, but we have solved it by providing an automobile and a light delivery truck which enable us to transport the classes rapidly to nearby private orchards. With a small class we can guarantee the owners that we will not harm their trees. If the sections were large, this would be out of the question.

We are now planning to extend this idea by offering electives in the study of single fruits. Here I must digress a moment to explain that California is a land of specialists in farming lines. The general farm such as is known in the East and Middle West is here very rare indeed. As a consequence many of our students are interested in only a single fruit. Under our new plan if a man, after having the general course, desires to specialize on pears, for example, we will accommodate him providing four to ten men want the same work. By arranging for all-day periods we will be able to visit orchards twenty to forty miles away and get in considerable work. Our system of concrete, asphalt-covered highways enables us to travel every day in the year and only rain can keep us from work, as the winters are not cold, the temperature rarely going more than five or six degrees below the freezing point, and then only at night.

Other electives will be offered under the general title of "orchard problems." Through the farm advisers, county horticultural commissioners and in other ways the fruit growers will be invited to notify us if they have any tree troubles that need investigating. The students will be taken to such places and their task will be to find out what is the matter and apply the remedy, if there is one. Of course, the teachers would be expected to exercise judgment and not steer an inexperienced bunch of men up against some impossible problem right at the beginning. Hand in hand with the field operations, of course, would go a requisite amount of library work. A little preliminary testing of the plan described has shown that the growers will welcome this kind of service on the part of their state institution. Within a radius of 30 or 40 miles we will have available as laboratory material three famous fruit regions—two of them very old ones, viz., the Winters district, Vacaville and the Sierra foothills.

The final experiment we are seeking to put into operation this summer after the close of the regular session of the farm school is to enroll a few selected men for special instruction. Under this plan we will, for

example, sign up two to four men during July for an intensive study of the handling of an apricot crop. The men will work in the orchard nine hours a day under a regular instructor, or at times under the orchard foreman, in picking, packing and actually marketing the fresh fruit, and also do everything in connection with the drying of apricots. If a man shows proficiency he may possibly be made a straw boss and given charge of a squad of boys or girls engaged in cutting the fruit or of other hands who may be attending to the sulphuring or some other operation.

The students will be given school credit for this work, if satisfactorily done, at the rate of one unit for every thirty-two hours put in and in addition be paid a nominal wage on a sliding scale ranging perhaps from 15 cents per hour for the first week to 30 cents for the fourth week.

During the month of August we could offer similar instruction in handling peaches and in September prunes and almonds. At the proper season one or more men could be given a week's work in tree budding and instruction in many other lines could be offered from time to time. While this plan would be a material help in solving our labor problem in the handling of our rather large crops of fruit, we would want this fact to be decidedly a secondary consideration. And the same would hold true as regards the wages earned by the students, as we would want them to feel that the money they take in is far less important than the instruction received and the practical knowledge gained.

REPORT OF COMMITTEE ON UNDERGRADUATE WORK.

By B. S. PICKETT, *University of Illinois, Urbana, Ill.*

Your Committee on Undergraduate Courses notes with satisfaction the large number of papers offered on this year's program on subjects bearing on horticultural instruction, as such a considerable amount of attention to this phase of the work of the society indicates a highly laudable interest in efficient horticultural teaching.

Your committee conceives that among its functions are that of defining the trend of progress in its field, and of offering suggestive material for the consideration of the members of the Society.

In tracing the progress of horticultural instruction, it should first be said that there seems to be an ever more and more earnest endeavor to improve the pedagogy of horticultural instruction. This result obtains through more exact and comprehensive outlining of courses, through improvements in texts, through added equipment (cumulative to a considerable extent in well organized departments of horticulture), and especially to the development of laboratory methods of teaching. The laudable work of earlier committees of this Society, published in earlier volumes, has been of great assistance in the outlining of courses. Friendly rivalry among the instructors, with free exchanges of ideas, has been another potent factor in improving the pedagogy of our subject.

In connection with the presentation of horticultural courses I would call attention to a point frequently discussed in educational circles which

bears immediately upon efficiency in our field of instruction, namely; the relative value of equipment and instructor. Researches made by authorities in education seem to show that, relatively, equipment is a small factor, usually estimated at 15 per cent. This calculation, however, is based on a wide variety of subjects, including mathematics, English, and history and is an average of many conditions. It cannot, therefore, be expected to apply exactly to a specialized subject such as horticulture, where plants and their manipulation form an extremely important part of the subject material worked with. Moreover, what is true in the average has little bearing upon individual cases. There is no question that the instructor is much the largest factor in successful teaching, but the successful instructor may have his own efficiency indefinitely increased by furnishing him with the equipment necessary to present his subject clearly, fully, and forcibly. This leads logically to the conclusion that the horticultural instructor must exercise ingenuity to perfect apparatus and equipment especially adapted to the presentation of his subject, even as the physicist and chemist have done in their fields.

It is especially in the laboratory that progress has been marked in horticultural instruction in recent years. The recognition of the field laboratory in horticulture on a par with indoor laboratories in other subjects had had much to do with the advances in this direction. The need to acquaint city students with plant materials, the demand from orchardists for foremen with experience in fruit growing, and last but not greatest, the pedagogical correctness of field laboratory teaching, have placed us a long step forward in the development of courses in horticulture in many agricultural colleges.

Field laboratory work in horticulture presents certain difficulties which the instructor is often loath to cope with. First, it requires room; second, it requires reasonable proximity to classrooms, indoor laboratories, and offices; third, it requires considerable financial support for the purchase of materials, for the preparation of land, and for the care of plants located in the field laboratories; fourth, and most precious of all, it requires large shares of the instructors' time. Many laboratory exercises require a day or more in immediate preparation. Land may need to be plowed and cultivated, plants may need to be ordered and the order anticipated far in advance of the time of the laboratory exercise itself. Cultivating tools, planting tools, pruning saws, grafting tools, ingredients for grafting wax, scion material, stocks, packing and grading machinery, and scores of other details of preparation and apparatus must be arranged for and coordinated so as to make the exercise not merely possible, but a complete and enthusiastic success. Failure in small details destroys the students' confidence, and renders the exercise worthless. Complete command of details can only be obtained where the instructor spends an amount of time in preparation far beyond that required in most indoor laboratory work. The satisfaction, however, which results from a well presented and conducted piece of field laboratory work is a rich compensation to the enthusiastic teacher of this subject. But, again it must be repeated that it is to be attained only by the expenditure of that most precious of commodities, time.

Your committee notes and deplores the lack of instruction on the plant materials of horticulture. Specialization in one of the main branches of the subject has narrowed the field of knowledge of horticultural plants too greatly. It seems to your committee that a pomologist, or an olericulturist should have a broad acquaintance with ornamental plants, with some knowledge of their culture and habits, and that this knowledge should extend at least a reasonable distance into the field of systematic botany. Though a course, which to some extent provides for this lack, has been offered at the University of Illinois, to the speaker's knowledge for a period of twelve years, no student has ever elected it. The attention of the Society is called to this matter because it is connected immediately with the spirit of horticulture.

One other matter should be referred to in this report, namely, the effect of the war on horticultural instruction. On the immediate facts the committee can add little to the information already in the hands of the instructors in all of our agricultural colleges. These facts are the lessened attendance and the reductions in the instructional staff as a result of drafts and other causes immediately connected with the war conditions. This Society, however, will be much more concerned and interested in the effect which it is to play on the ultimate development of horticulture, for with decreasing attendance of students two things are likely to occur, economies in teaching, which means reductions in teaching staff, and a laxness in the presentation of the subject which is likely to come when classes are small and where men's thoughts and hearts are distracted by the outcome of the war. Economy by state legislatures in supporting departments of horticulture may well result in the drawing in of lines, and a slowing up of efforts in the direction of progress in horticultural instruction.

The British soldier has given us two significant phrases in connection with the war, the first, "do his bit," and the second, "carry on." This is clearly the time when instructors in horticulture should do their bit to maintain and further advance the presentation of their subject. The phrase "doing one's bit" has been criticised as being too narrow, and efforts have been made to substitute for it in this country "doing one's best," or "not only our bit but our best." The phrase usually loses its significance when interpreted in this manner, for few, perhaps none, of us ever realize our best, while all of us may do our bit. An instructor who modestly refers to his efforts as doing his bit has probably accomplished more than he who more or less bombastically declares he has done his best.

And the phrase "carry on" is even more significant, for it is the cheery call to advance in the face of difficulty, a modest deprecatory phrase which carries with it a world of sincerity and determination. Through the period of the war the horticultural instructor must carry on hopefully and with sincere determination the task of improving his presentation of his subject and the effectiveness of his teaching.

METHODS OF PROVIDING PRACTICAL WORK IN HORTICULTURAL COURSES.

By S. W. FLETCHER, *Pennsylvania State College, State College, Pa.*

Twenty five years ago when I was an undergraduate at one of the leading Eastern agricultural colleges, no practice whatever was given in most of the courses in horticulture. The professor lectured us faithfully and occasionally took us out for a stroll in the orchard and garden. Were it not for the very fortunate circumstance that I was obliged to earn my way through college and to this end secured work in the Horticultural Department, I fear I should have graduated without ever having used a garden line or budding knife. Happily, there has been considerable progress since then, but more emphasis still should be placed upon this practical work in college courses. We do not wish, however, to turn our agricultural colleges into trade schools. The time may come when most of this practice will be secured in secondary agricultural schools, but at present when a majority of our graduates enter the commercial field it is necessary to combine the art with the science in college instruction. Agricultural colleges now graduate men in horticulture who have never had any training in the art except that secured in a few brief practicums. These men are likely to bring discredit upon the department among its chief constituent—the practical fruitgrowers, gardeners and florists of the state.

By real practice, I mean not a series of two-hour practicums in which the student is merely introduced to the subject, nor trips to observe the methods of commercial growers, however desirable these may be; but a considerable period—a full year if possible—spent in doing the work of the orchard, garden or greenhouse. A large and increasing proportion of horticulture students come from cities and towns. It is not quite fair to accept these students, carry them through four years of lecture work with brief practicums interspersed, and then penalize them at graduation, when they seek positions because they have had no practice. The college should either give it or see that the student gets it.

The choice of the method of giving students instruction in horticulture is determined mainly by the location of the college and its equipment. In most colleges the sole means is the practicum. These are useful, but the time allotted, usually but two hours a week, is hopelessly inadequate for real practice. At the Pennsylvania State College, the practicum periods in pruning, spraying, harvesting and packing fruit, have been extended to four hours each. This is proving to be a distinct advantage. Some colleges are so fortunate as to be located close to large private commercial operations in horticulture. The field practicum or inspection trip then becomes practical.

Both college practicum and inspection trip will continue to be used, especially in the elementary courses, but they do not go far enough. They are necessarily intermittent and fragmentary. They do not give

the student an insight into the problem of the commercial grower as a whole. They do not fairly represent the yearly cycle of work and responsibility that he must meet. A period of practice covering, if possible, at least one full year is necessary. Some institutions require the student to have had a year of farm life before entering college. Others require him to secure this experience during his course, either by summer work in a commercial establishment of his own selection, or on accredited farms chosen by the college. These methods fail fully as often as they succeed. The student rarely sees anything but the drudgery of the farm, and often loses interest. The placing of students on accredited farms is desirable only when the employer is distinctly successful in his work, and is the type of man who will take a personal interest in the student.

For some years the Pennsylvania State College has required all students in horticulture to take "Hort. 17, Summer Practicum." As originally conceived, this was to comprise "six weeks of survey work in commercial truck gardens, florists' establishments, orchards, nurseries and small fruit plantations," and counted six credits toward graduation. In practice this has become merely an inspection trip, dwindling gradually from six weeks to three. The college is quite remote from commercial orchards, gardens, and greenhouses. For this reason it has been decided to develop commercial operations at the college for purposes of instruction. A commercial orchard of thirty acres, with opportunity for expansion, has been planted two miles from the college. As funds will permit, this will be provided with packing shed, spray shed, common storage, superintendent's house and other equipment essential to a commercial plant. It will be handled on a commercial basis and used for giving students instruction in commercial operations. Ultimately, it is planned to provide housing accommodations for a limited number of students. The present summer practicum then will be extended so as to require all students specializing in pomology to spend one full growing season on this farm, where he will perform all the orchard operations under the direction of the superintendent. This will not be run as a "Model orchard" but as a laboratory in commercial fruit growing. Similar provision will be made for the work in commercial vegetable gardening. We recognize fully the difficulties incident to the successful operation of such a plan, but believe it is the most feasible plan for an institution that is remote from private commercial operations. It might not be necessary or practicable in an institution located with easy access to commercial plants, as at the Ohio State College and Rutgers College. Whatever the method adopted, the aim should be to provide the student in horticulture with facilities for practical work at least equal to those now provided for the student in dairying. The lack of such facilities in the past has constantly worked to the disadvantages of the courses in horticulture.

COURSES IN POMOLOGY AT CORNELL UNIVERSITY.

By W. H. CHANDLER, *Cornell University, Ithaca, N. Y.*

The purpose of this paper is not to advertise the courses in pomology at Cornell University, but to make use of that list of courses in a discussion of views concerning education in pomology. In fact, while the arrangement of courses to be described seems to us wise, it is very doubtful if for any other group of teachers, or under any other set of conditions this would be the best arrangement of courses. Briefly, the conditions under which we work are as follows: We are under the elective system, there being no required courses in applied subjects. Before the beginning of their senior year, all men must satisfy a Farm Practice requirement so exacting that men reared on farms have been required to get additional farm experience. Freshmen who have not yet met this requirement generally begin working on a farm during the summer after their first year. This farm practice requirement is a prerequisite to our first course. A very large percentage of the farms in New York have orchards on them. Nearly all of our students, then, will have had orchard experience before taking our beginning course.

The beginning course is a general one giving three hours' credit, one of which is for laboratory work. It covers the entire field of temperate zone fruit growing. It seems better thus to cover the whole subject of pomology in one course, both because we think it better for students specializing with us to begin with a general view of the subject and advance by going more minutely into its problems, and because such a course is well adapted to the needs of students who are not specializing in pomology. It has been found possible rather fully to cover the subject in a two hour lecture course because of our method of assigning readings on each subject and giving a ten minute examination in advance of its being considered in the lecture. The teacher then may spend his time considering problems rather than details. We also save time by leaving some details for discussion in the laboratory where they will be more easily grasped in connection with the actual experience.

Our next course is in Varieties and Judging, a one hour laboratory course.

The next is a course in Fruit Packing. This course is given by the extension professor who is expected to give only one term a year to extension work in the field. It is, of course, expected that the students will acquire skill in the different methods of packing of most fruits, and also a critical knowledge as to the value of the different packages in marketing as for apples, barrels, boxes, cartons, etc. It is hoped that these trained packers going back into the state will be of much assistance to the extension professor in his effort to encourage communities to adopt the central packing shed.

The next is a two hour course in Systematic Pomology. While more stress is given to species that can be grown in our plantings, the course considers all fruit bearing species concerning which anything interesting can be learned. Except what can be learned by actual

touch with the plants little attention is given to taxonomic descriptions. More attention is given to the physiological characteristics that determine cultural practices. It is thus rather more of a course in fruit crop ecology than one in taxonomy. In most of those fruits that are not available in a growing condition for study an effort is made to have the student get his information from the writings of men who have had actual experience with them, the teacher assisting the student in interpreting the literature.

The next course is a trip through orchard sections conducted just before the beginning of the fall term. It is hoped that the student's view will be much broadened by seeing the different methods practiced by equally successful growers. He should thus be in a position more intelligently to evaluate both the opinions of growers and the results of research.

The next is a two hour course called Experimental Pomology and is a study of the evidence concerning orchard practices. Naturally, experimental results that have not yet become of value in practice are studied as to their possible contribution toward solving orchard problems. Very little lecturing is done. The student is required to read the important literature and the hour is spent by the students and teacher in an effort to interpret or evaluate that literature. No student is admitted to the course who has not had training in botany, including plant physiology, and in chemistry.

An advanced laboratory course is offered in which it is hoped that those men specializing with us who expect to become teachers, etc., will acquire some skill in practical orchard and nursery work.

A few students are admitted to another course called Research (which of course it is not) in which they are permitted to work individually in the library getting minute acquaintance with the literature concerning certain crops in which they may be especially interested.

Undergraduates may attend our seminar, but can receive no credit because we have found that a seminar which includes a number of undergraduates working for credit is very uninteresting.

I wish again to emphasize the fact that I do not consider this an ideal arrangement of course. I wish, however, to discuss these courses with reference to what we omit, what we include, and what we try to accomplish.

We omit courses in special crops such as small fruits, because all fruit crops seem to have so much in common, that there must be much repetition if such separate courses are given. Discussion of the various practices as the exact manual details of thinning fruit, is omitted except as it can be given in the field laboratories. I have known as much as three lectures to be given to a class of nearly three hundred students on the details of thinning. Of course, it is evident that very few of these men would be any safer to send into an orchard to thin fruit from having been entertained in this way, any more than a mule would be increased in value by having heard a lecture on the art of working in harness. It is our view that only such routine details of orchard practice should be discussed as are necessary to an understanding of any problems involved. In other words, lecture courses in a college

should deal with that concerning which a grower must give serious thought rather than with description of routine, manual details, which he performs almost subconsciously.

We include every hour of laboratory work that is possible with our equipment. During the past three years the number of hours of laboratory work offered has been doubled, while the number of lecture hours has been reduced one-half. As previously stated, we include as much as possible of experience in evaluating practical and experimental evidence. All of the final lecture course is devoted to that. We do not consider, however, that the student specializing in pomology secures any large part of his training in that department. He is required to secure a considerable amount of training in botany and chemistry, and also to take courses in soils, plant pathology and entomology besides, of course, other elective and the required courses in the college.

What we hope to accomplish, then, is not to turn out skilled orchard laborers, an impossibility for an agricultural college, but to send out thinkers who will be able to meet the new problems that arise with every season, weighing critically and intelligently all experiences and opinions and sometimes, at least, arriving at the truth. Perhaps it is from want of modesty, but we hope that this critical weighing of opinion and the results of experience in pomology together with the habits of accuracy acquired through his training in the laboratories of the fundamental sciences, may enable him at least slightly more often to arrive at the truth in other affairs of life. When the student does not pursue any subject far enough to acquire critical knowledge (and he is often prevented from doing so by the courses not being planned for such a purpose) he would seem to be always too much dependent in his views upon so-called authorities. A man may become known as an authority because he has been so successful in his pursuit of knowledge that the usefulness of his findings makes him prominent. Even that would not make all of his views worthy of acceptance without weighing, but he may also become known as an authority because of his personality or of his ability to dramatize his acts or sayings or because like Mark Anthony, "he only, speaks right on." When a man has acquired, by practical and by diligent and critical study of the results of experience recorded in the literature, the ability to evaluate with some accuracy the opinions of men in one line, it would seem that he would find such training of some help with other problems concerning which he will have to make decisions.

Thorndyke says, "The advisable course in estimating beforehand the disciplinary effect of any study, occupation or the like, would seem to be to list as accurately as possible the particular situation—response connections made therein. * * * what connections it forms that carry vital maxims, notions of method, ideals of accuracy, persistence, verification, openmindedness and the like." The problems in pomology require for their solution exceptional patience, accuracy, and the ability to make use of a range of critical knowledge. Certainly the problems of life are of this kind. It would seem then that courses in pomology together with the prerequisite courses in fundamental sciences may be so arranged as to give the student training that will assist him in meeting not alone his problems in fruit growing, but other problems of life also.

POMOLOGICAL FIELD LABORATORIES.

By E. W. BAILEY, *University of Illinois, Urbana, Ill.*

The value and importance of laboratory instruction in horticultural courses have been emphasized time and again before this Society in papers and discussions on teaching methods. I doubt whether there is any subject that lends itself better to the laboratory method than that phase of horticulture called pomology. By laboratory instruction in pomology, we might mean demonstration in which the instructor goes through an operation such as the pruning of an apple tree before his class, trying to point out the art and the fundamentals that underlie the operation; or it might consist of an exercise conducted within the class, greenhouse, or laboratory room, where each student actually practices the art as well as attempts to understand the fundamental principles that underlie the operation involved; or laboratory instruction in pomology more often (and rightly so, I think) consists in the practice being done in the field, the orchard laboratory, by the student carrying forward, largely on his own initiative, the operation concerning which he previously had been instructed in the lecture room. Right at this point, I might say that I am not so sure from my experience, whether it is better to lecture before, or after a laboratory exercise on the subject matter taken up in the field laboratory. I am inclined to think this varies with different topics and in some cases the lecturing, if necessary, can be done at the time the laboratory work is being carried on. All of these methods, with other modifications, might be used satisfactorily in the laboratory teaching of pomology, but it has been my experience that by far the greater number of the facts, as well as the art, can be most efficiently taught by actual first-hand contact with the tools, materials, and problems of commercial production in the field laboratory. Laboratory work of this nature is always concrete, and, since the students' sense of values comes largely from commercial sources, field practice is best adapted to the development of traits required for a successful vocational career. However, I am mindful of the difficulties of the increasing number of students, distance of field laboratories from the lecture room, complicated curricular demands upon students' time, as well as lack of suitable facilities for the development of the right sort of pomological field laboratories, but, it seems to me, that these difficulties must be overcome; as it is of primary importance that field laboratory instruction be carried on in pomology, if we would efficiently develop successful pomologists either in the practical or professional field. At the University of Illinois, over 50 per cent of our agricultural students come from Chicago and other large cities, and it seems to me that if we intend to find the future pomologists of a group like this, knowledge of pomological materials, as well as the facts of pomology, can best be successfully taught by means of well developed field laboratories. If our democratic education in our state institutions is really to do justice to the individual to make for the highest efficiency

of society, pomological education must attend carefully to the laboratory method as a means of "putting the round pegs in the round holes and the square pegs in the square holes"

Realizing the values to be derived from such laboratory method and being situated distant from most of our large commercial fruit growing areas, the Department of Horticulture at the University of Illinois, with the purchase of a large tract of land in 1911, has been working out a system of field laboratories that would, in some measure at least, successfully take care of our instructional work in field practice. I have had the good fortune to be associated in the development of the laboratories for Systematic Pomology, and I would like to bring to your attention some of the things I have attempted to work out in connection with a plan for a field laboratory for advanced pomological students.

This laboratory contemplates a series of annual deciduous tree fruit plantings for a period of years, each successive planting being a duplication of the previous year's planting in the closest possible detail. By the co-operation of one of our best nurserymen, together with detailed records, duplication of the same grades of nursery stock should be made possible year after year. Each annual series of trees so planted will be divided into plots and each of these plots will in turn represent a test, or experiment attempting to illustrate and demonstrate some known fact, or facts, pertaining to the science of pomology, or the practice of this art. These plantings are made by the students as part of their regular laboratory work in connection with their advanced undergraduate courses in pomology and each succeeding class will have the previous plantings as materials from which it can make comparisons and draw conclusions.

Many of these plots are designed especially as student "projects," or "problem questions" for the specific purpose of allowing each student to work out the facts and practices regarding some detailed pomological question. These "projects" would be assigned in connection with the development of the entire annual laboratory planting, as far as possible, according to the aptitude of the students, in such a manner that each student might work out largely by his own initiative outside the regular class work (just so it didn't interfere with the general development of the field laboratory), at least one specific "project" during his course. Such "projects," through proper leadership of the instructor, should create attention from the student, increase initiative, interest, and desire for knowledge, as well as leave a personal appeal. Such laboratory method should, it seems to me, be of inestimable educational value and should materially help to determine graduate timber among the undergraduates.

A pomological field laboratory of this nature, developed by advanced undergraduate students under proper supervision and based upon tests and experiments dealing with the fundamentals and facts of pomology, should year after year become more and more valuable for laboratory instruction. As the series reaches bearing age, the tests and experiments should be varied and a definite plan with this end in view could be worked out dealing more specifically with problems of bearing orchards.

Such a system of pomological field laboratories might, after a period of years, offer ideal materials for graduate students, and, if this plan were efficiently executed, it would doubtless open up problems for suitable graduate research. A unifying of the advanced undergraduate and graduate instruction in a well developed field laboratory based on definite experimentation, which might in some cases be incorporated in experiment station projects, would lead, it would seem to me, to an efficient and successful method of handling advanced laboratory instruction in pomology.

REPORT OF COMMITTEE ON GRADUATE WORK.

By M. J. DORSEY, *University Farm, St. Paul, Minnesota.*

In the past reports of the committee on graduate work, it has been shown, first, that on the whole, workers in the field of horticulture are not on a par with respect to academic training with the men in some other branches, comparison being made directly with chemistry. Second, there has not been a unanimous opinion as to just what should constitute graduate work in the field of horticulture. Some have laid emphasis upon the *materials* of horticulture, and others on the *underlying* sciences. Third, there is some doubt as to whether graduate work should be given in horticulture or in the fundamental sciences. Twenty-four of the correspondents being in favor of offering graduate work in horticulture and eleven in the fundamental sciences. Fourth, there was almost a unanimous opinion among horticulturists that there should be a close relation between station projects, especially the Adams Fund projects, and graduate thesis investigation. The last statement appears contradictory to number three and is significant in this connection in that it is suggestive of a changing point of view.

The report of the committee this year will cover that part of the graduate training covered by the thesis. We shall confine our attention primarily to: first, the place of the thesis as a part of graduate training, and secondly, to a detailed discussion of the thesis.

THE PLACE OF THE THESIS IN GRADUATE TRAINING.

It would appear axiomatic that the type of training required of men who enter any field of applied science would be fairly closely allied to the type of research most urgent or most important in the field in question. In the previous discussions on the subject of graduate work, emphasis has been placed upon the distinction between the type of training of the man who enters the field of horticulture in its applied sense and those who enter it from the standpoint of research. There are clearly then two points of view, the so-called practical view and the scientific view. The fact that these two views are both represented in the faculties of today makes it certain that two types of graduate work will be given and consequently with respect to training two types of men will be developed. It may also be stated that there are two types of problems confronting investigators in the field of horticulture, first,

problems requiring for their solution a knowledge of the materials and methods of horticulture in the applied sense, and second, those confronting the industry which require a knowledge of the fundamental or underlying sciences for their solution.

The attempt to make this distinction is persistent and determined. It carries with it the implication that scientific work is not practical, since the practical investigation is assumed to be practical. It is not the intention to enter a lengthy discussion of this point here, but the crux of the whole question is this: are workers trained with the two points of view interchangeable, that is, can the man with the scientific training approach problems in the applied sense and can the man with the so-called practical training approach problems in the scientific sense? The fact is, that at times the argument on this point resolves itself into a matter of self-defense, that is, the practical man excuses his lack of scientific attainments on the ground that he is a practical man and the scientific man defends his short-comings in a practical way on the basis that he is a scientific man. This question should not be confused with the immediate applications of the results of investigation, but the element which enters most persistently in making this distinction is the fact that the immediate applicability of scientific investigation is not in all cases evident. From the standpoint of graduate training, the important thing to be kept in mind is that some men with a scientific training are also practical and that some with a practical training are also scientific, and consequently there is nothing inherent in one viewpoint or training to prohibit the entrance of the other.

With this situation at hand, what then is the object or the place of the thesis in the graduate training? The thesis may be looked upon from two standpoints; one, as an instrument in training the mind, and the other as a measure of the man. As a feature of training and as a point of entrance into a science, the thesis has its function in giving the graduate student an opportunity on the one hand to sum up the knowledge known, preferably on a specific problem, and secondly to add to knowledge in that field.

It will be recalled that in some of the reports last year, there was a tendency to limit the master's thesis to merely a summing up of knowledge, leaving the second phases primarily to the longer term work covered in the doctor's training. The committee holds to the view that, thesis work for the master's degree should include at least an attempt at investigation. By original investigation we mean broadly a method of attack which will bring out new facts.

The chief distinction between the training obtained in original investigation and course work lies in the point of view. In the one case the mind is receptive and in the other creative. One attitude is essentially static and the other active or progressive. So it would appear that the thesis as a part of graduate training can have a different value, according to its direction or nature and that a literature review, or a summarizing thesis is in its point of view in line for the most part with course work.

The work done by a graduate on his thesis furnishes his chief recommendation to others. In the course work, if properly given, there are ample space and time for a rather broad summary of the field, without leaving this to the individual initiative of the student, to be covered in the thesis which is, for the most part, a review. The relation of the thesis then, to the remainder of the graduate training is that it is supplementary, and different in its point of view.

When a subject is taught from the research standpoint, it is relatively easy for the student to get the point of view of the way in which facts are developed in science and to attack a specific problem of limited extent, bring together what is known and then go farther. It is going farther which gives a student the opportunity to handle proof, technique and methods, to make deductions, to handle facts and to draw conclusions. Course work can be presented in such a way as to include these, but his training should come primarily in learning to use the tools that others have used, or if necessary, perhaps to invent new ones, and in their use a new clearing may be begun, or an old one cleared better.

The difference in the point of attack may be illustrated as follows: Take for example, the ancient question of the graft union. A purely horticultural aspect of this problem would be to determine which stocks are best for a particular fruit, considering such points as productiveness, the relative speed of growth of stock and scion, and the permanence and readiness with which the union may be made on a commercial scale in the nursery. This would be the horticultural or practical phase of the relation between the stock and scion. Another phase of this question may be termed the anatomical, which would include a study of the graft with particular reference to the cell union, and the laying down of conducting tissue through the point of union. Again the problem may be approached from the cytological standpoint, including a detailed study of cell contents, structure, and division in the region covered by the graft union. Still another phase may be termed the chemical, which could be made to include, for example, a microchemical study of the cell contents in the stock and scion in the region of the union, or an examination of the raw material below and above the union. Finally, the problem might be largely physiological, which, broadly, could include an examination of the influence of the stock on the functional activity of the scion. Checks may be made upon such points as rate of transpiration, rate of growth, starch content and stored food in twigs.

The problem of the graft union is mentioned to illustrate the points of attack and some of the underlying sciences involved in what appears to be a horticultural problem. It will be evident that what has been regarded as the horticultural aspect only goes so far, and that an accurate conception of the relation between stock and scion cannot be gained until an investigation is made from different points of view.

If there is a distinction between the practical and a scientific phase of an applied problem, it is not necessarily true that graduate training should follow along these lines. The limitations of each type of training should be clearly recognized. Our final statement on this point is that a

man scientifically trained may carry forward accurately and with careful control, important investigations in strictly applied problems, but a man of the so-called practical training is not necessarily able to carry forward research of a technical nature. There are then, limitations on the one type of training not inherent in the others.

THE THESIS.

The thesis outline as generally presented may be briefly summarized under the following heads:

- Table of contents.
- Introduction.
- Acknowledgments.
- Literature Review.
- Statement of the Problem.
- Material and Methods.
- Results of the Investigation.
- Discussion.
- Conclusions.
- Summary.
- Bibliography.
- Plates and Figures.
- Publication of Thesis.

As a basis for discussion, these different sections of the thesis will be given separate treatment.

Table of Contents: The table of contents should follow the title page of the thesis and should include, with proper subordination, the main divisions of the thesis outline. If the table of contents is carefully worded and arranged, particular attention being given to subordination, it can be made to present in summarized form not only the main points covered in the thesis, but the thesis outline as well. By careful reference to the paging, the table of contents also serves as a good index to the thesis, especially if the main headings are well divided in the text. The main divisions of the subject and the table of contents should correspond. The main divisions can be made center heads in the text, the next divisions under the main heads also center heads but of a different type. The divisions third in the rank in the table of contents can be included in the text as italicized side heads. Where further divisions are made these can be given the rank in the text of paragraph subjects. The table of contents then can be made to serve the double purpose of an outline and an index.

Introduction: In the introduction is generally stated the point of view. It is true that there are a great variety of introductions, as many probably as there are writers. A careful statement in the introduction giving a philosophical and historical setting for the problem to be presented will in most cases be good form. In order to do this a lengthy introduction is usually not necessary. In many cases no distinction is made between the introduction and the literature review, but if carefully done, the introduction can present the author's point of

view in a way that cannot even be done in the summary or discussion.

Acknowledgments: Acknowledgments of the author to instructors or associates are sometimes placed after the introduction, sometimes after a discussion of the materials and methods and sometimes as a final statement at the end of the text, and also sometimes as a foot note on the first page. The committee believes that preference should be given to a foot note at the bottom of the first page or a statement following the introduction. The acknowledgments should be simple in statement and to the point. Whatever the personal feelings of the author may be, viewed from the standpoint of dignity and time, a plain simple statement of the facts will avoid future embarrassment. Courtesy extended in this way, fairly and accurately, is a measure of the writer's good taste.

Literature Review: In the literature review, the author has an opportunity to present his conception of the relation between his work and the work done previously by other investigators. In many problems there is an extensive literature and the author must of necessity exercise care in the choice of references to be included. It is entirely proper for the author to present a review only of those works which in his judgment can be considered as real advances in the particular field in which he is working. A complete historical statement of all work in a particular field, and a review of those contributions to research which have been real advances, are in most cases decidedly different. The latter can be made short and to the point. The mere summarizing of the work done by each author and presented paragraph by paragraph gives the reader but little conception of the author's point of view. If, however, instead of this type of literature review, the author has as his theme the development of the idea leading up to his work, and uses the names and contributions of others as merely incidents in the theme, the author then leads up to his point of attack, at the same time taking the mind of the reader to the problem, rather than leaving the theme to be worked out by the reader. The literature review is easily overdone, likewise it is easily underdone and extreme care should be exercised in presenting this phase of the thesis in order to be fair and accurate.

Statement of the Problem: Following the literature review in which the theme has been developed up to a point where taken up by the investigator, a statement of the problem is in order. This can be made very brief since an extended treatment at this point would for the most part have to be presented later. In the statement of the problem, the author has an opportunity to present his view of the place his research takes, and the way in which it builds upon the work done previously in his field.

Material and Methods: Under this heading a statement should be made of the material and methods used. The author can show his fairness as an investigator by the frankness with which he discusses both the strong and the weak points of his materials and methods. There need be no reserve exercised in this connection or any hesitancy in stating the full facts, since the purpose is to place before the reader

a complete statement of the facts from which conclusions were drawn. If it is necessary to present a description of any new methods or apparatus it can be done under this heading, even though it may seem necessary to discuss certain details in connection with the presentation of the results of the investigation.

Results of the Investigation: This division of the thesis is the most important and the treatment thus far should be made in such a way as to lead up logically to the presentation of results, which may be done by means of descriptions, tables, photographs, drawings or curves. The material included should be carefully selected and the arrangement should follow a carefully planned outline in which the point of attack is automatically revealed. In most cases the presentation of results is too extensive and detailed, instead of being carefully summarized. In some laboratories it is not uncommon to see graduate students weighing their thesis manuscripts from time to time to note progress. Some judgment must of necessity be exercised in order to include primarily only the material which is contributory or basic to the conclusions reached. If the field is new, there are always a number of side issues which may, if presented, render it difficult to determine which is the "main show." Here again, the mere succession of table on table or curve on curve with scarcely a connection between them cannot be considered good form, to say the least. Through the presentation of the results of the investigation should run the main theme of the research. The presentation of data can be made in such a way that they fit into the text statements and follow logically one after the other. If the results are presented from this standpoint the discussion of the results can be shortened materially.

Discussion of Results: Under the heading of "Discussion of Results" the author has an opportunity to show his openness of mind and his fairness and honesty as an investigator. At this point the writer can take up the theme left off in the literature review and make the final analysis of his research and placing the facts brought out in their proper relation to others, in the same field, already known. The discussion can be made brief and to the point, coinciding with the viewpoint expressed in the introduction. It is frequently necessary in a discussion to present brief statements concerning other work, as a basis for comparison. This seldom need be extensive, however, unless the field worked in happens to be one under controversy and attacked by a number of workers.

Conclusions: The conclusions are sometimes expressed in a numbered series in such a way that they comprise simply final statements of the results of the investigation. The main object of the conclusions, as it appears to the committee, is the point in the thesis where a statement can be made of the scientific deductions which seem to be justified as a result of the facts developed in the particular investigation in question. These are usually not extensive even if the work has been intensive and thorough. The conclusions are presented quite frequently in the form usually followed in the summary. A distinction needs to be made between conclusions and summary.

Summary: In the summary the author should present a series of statements bringing out the main points of the entire thesis. At the end, the final statement can be made to include the conclusions. If the summary is presented properly and from the right point of view the main theme of the thesis will be contained therein, with the exception of the details upon which it is based. The object of the summary primarily is to present to the reader a statement of the work without going into the details of the presentation. The author should keep in mind that it is through the summary that most readers are reached.

Bibliography: A distinction should be made between a bibliography and a citation of literature. A bibliography is the more inclusive and can be made to contain all of the principal references in the particular field. The literature cited should contain only the references mentioned in the text. In referring to the works of others, different methods are used. Sometimes where reference is made direct it is included in the text. At other times it may be mentioned in parenthesis. The literature may be either cited at the end of the thesis or at the bottom of each page where reference is made, in foot notes. The two methods have certain advantages. Where references are made at the bottom of each page the convenience of the reader is primarily considered. Where it is made following the summary, the necessity of turning to each page to get the reference in the particular field is avoided. In the bibliography of citations of literature, chronological order is sometimes followed, in which case the year of the reference is placed aside at the left of the page. In other cases an alphabetical arrangement of the authors with a chronological arrangement of the works of each author is used. There are various forms of presentation, such as that followed by the Botanical Gazette or the Journal of Agricultural Research. The main point is to have some acknowledged system and follow this religiously in every detail or form, punctuation, capitalization, volume, page, plate and figure reference.

Plates and Figures: Plates are generally placed at the end of the work, although in many cases for convenience, they are placed in the text. The text figures should be numbered serially and reference should be made to them only when necessary in the presentation. The legend in the text for a figure should be complete and of such a nature that the figure or cut can be completely understood without hunting for the text reference. In the plates, which are generally placed at the end of the thesis the same system should be followed in the legend. The committee feels that the most convenient system is to number the plates serially, where there are more than one, and then number the figures serially. For instance, there may be four plates and sixty figures. If the figures are numbered in order in the plates, awkwardness in the text reference is avoided, since merely the figure number, without the plate number, can be used. If there is a number one in each plate, it is necessary for both the reader and the author to keep this constantly in mind. Where it is necessary to refer to more than one point in a particular figure, letters can be used. If possible, the legend for each plate should be placed on the page opposite the particular plate so

that when the volume is open at this point the figure legend and the plate are available without a turning of the pages.

In the choice of illustrations or drawings, the author again has an opportunity to show good judgment. These should be as brief as possible and yet ample for the purpose of bringing out the important details which the author deems it necessary to illustrate.

Publication of the Thesis. There may be some question regarding the publication of the thesis. The committee holds that except in those cases where the thesis constitutes a part of a larger project and publication is withheld for that reason, that any thesis, and certainly the doctor's thesis, which is not worthy of publication, is not worthy of acceptance for partial fulfillment for the degree. The thesis can be presented in such a manner and with such finality of treatment and criticism that it is ready for publication without changes. It is sometimes necessary to withhold it for further data, but along with the experience of preparing and presenting a thesis may also be included the experience of preparing it for publication. It would be entirely proper to have the departmental criticism come to the thesis before it is presented to the graduate faculty. In fact, considerable embarrassment may be avoided by having careful department criticism at this time.

SATURDAY, DECEMBER 9, 2 P. M.

ELECTION OF OFFICERS.

Two lists of candidates were presented by the nominating committee and the officers and committees listed on page 5 were elected for 1918.

OLERICULTURE AS A FIELD FOR INVESTIGATION.

By T. C. JOHNSON, *Virginia Truck Experiment Station, Norfolk, Va.*

The early investigations in olericulture, as in most other lines of horticulture, sought immediate results for publication.

This desire for quick reports influenced the type of work undertaken directing attention to problems lying somewhat on the surface of the subject. Immediate relief for the difficulties of the practical grower occupied the time and facilities at disposal to such extent that investigations requiring a long term of years were impossible, and the theoretical side of questions was necessarily held in abeyance while utilitarian ends were pressed.

The most fruitful cultural methods in the field and greenhouse received constant study, and spraying has been of importance from the beginning, giving rise to questions of what chemicals to use, when to apply them, and by what means. The nutriments adapted to the best growth of different vegetables has always required the advice of scien-

tific men, which gave early prominence to fertilizer investigations. These were largely a search for the combinations yielding the largest harvest with less inquiry into the reasons for success or failure.

The popularity of variety testing is apparent from a mere casual survey of the early volumes of the Experiment Station Record. Selecting apples and tomatoes as typical examples, it is interesting to note that of the 289 apple entries listed in the first six volumes, twenty-three per cent treated of varieties, or variety testing in some form, and of the 275 tomato entries, thirty-four and one-half per cent deal with variety studies.

After a lapse of twenty years, we find that of the apple and tomato entries in volumes thirty-one to thirty-six only three and one-half per cent of the former, and ten per cent of the latter, deal with variety studies in any form. It will thus be seen that the trend in the investigations of both fruit and vegetables has been away from variety studies.

As workers, with their varied specialties, have multiplied, and facilities permitted, many new and intricate olericulture investigations have been undertaken.

The major and minor projects now under investigation at the various experiment stations, bearing directly or indirectly upon olericulture as listed by the States Relations' Service, United States Department of Agriculture, may be divided into the following classes:

- Cultural and forcing experiments.
- Variety testing and classification.
- Plant nutrition and fertilizer studies.
- Plant breeding.
- Storage and marketing problems.
- Physiological and biochemical studies.
- Insect and plant disease studies.
- Miscellaneous studies.

CULTURAL AND FORCING EXPERIMENTS.

This class of problems continues to have a prominent place in our activities. In some instances the object seems to be to meet demands for immediate information on the art of growing a few of the newly introduced plants, or of improved cultural methods for others. This has its practical bearing, and a limited amount of time should be devoted to it. In others a search for the underlying principles on which sound cultural practice may be founded seems to be the object. Many of the factors underlying the relationship existing between culture, soil moisture, soil temperature, and their influence on the plants' ability to obtain nutrient materials from the soil, are yet unrecognized. Our knowledge of the relations existing between cultural and forcing methods, and the susceptibility of the plant to certain forms of disease, is very meager. We know, in a general way, how to control blossom end-rot of tomatoes in the greenhouse, but do we know what modification to make in our field practices to accomplish the same end? What are the factors that render the field tomatoes susceptible to this disease, and how

may they be modified or changed so as to eliminate this source of loss? The pathogenity of the disease may be known, but is it amenable to cultural treatment?

The vegetable growers in the Middle Atlantic and Southern States are often bothered by the presence of nematodes in their garden soils. Frost is an important factor in controlling these in the cooler portions of the country, but this method is inapplicable to the South. It is known that they can be eradicated by growing non-susceptible crops, but are there any cultural methods or practical soil treatments that will accomplish the same results?

VARIETY TESTING AND CLASSIFICATION.

The study of variety, and varietal characteristics, has not been fully superceded by other lines of activities, and it is not desirable that it should be; but the investigator should have a clear conception of the object sought. There is a vast difference between the variety testing for the mere purpose of determining relative productivities, and a search for principles underlying variations or adaptations. The practical grower is primarily interested in the productivity of his plants, and this justifies a limited amount of investigation. But in connection with this, a study of adaptability to soil and climate should be made. A knowledge of variations occurring under different conditions, and the factors influencing them, are of much value in classification studies.

This class of work may properly include studies of disease and insect susceptibility. The result obtained in developing wilt-resistant strains of cotton and cow peas is only an indication of what may be accomplished, and should stimulate us to greater efforts to obtain wilt-resistant tomatoes, cucumbers, cabbage and other vegetables.

There is a great need for variety study work to be put on a more systematic basis, so that the results obtained in the various parts of the country may be comparable. The present chaotic state of vegetable nomenclature needs systematizing, and this can be done only after a comprehensive study of the varieties under varied cultural conditions.

Noted examples of variety studies of high order include the work done by Stuart on classifications of potatoes; that by Myers on cabbage, and that by Fletcher on strawberries.

PLANT NUTRITION AND FERTILIZER STUDIES.

The subject of plant nutrition and use of fertilizers, as exemplified in olericulture, is a fruitful field for study. This is due partly to the large variety of plants and the varied conditions under which they are grown, and partly to the numerous sources of fertilizer materials from which to select.

There have been many experiments to determine the effects of fertilizers on texture, flavor and color of fruits, but few on vegetables. It is well known that potassium sulphate produces a better grade of

tobacco than does potassium chloride, but their relative effects on cabbage, lettuce and spinach are open questions. Many sources of nitrogen are available for fertilizer purposes, but the effects of the various kinds on the physiological conditions of the plants are not definitely known. Sodium nitrate is frequently used to stimulate foliage formation in parsley, but does it give better results than cyanide, and if so, why?

Do the kind and quantity of fertilizers used have any influence on the plants' power to resist disease? If so, why? Can we produce vegetables profitably by the use of commercial fertilizers alone, or must we use them in combination with animal manures? What is the effect on the soil and on plant productions, of continued use of large quantities of commercial fertilizers? What is the effect of animal manures in vegetable production? What are the factors that determine the influence of commercial fertilizers on the soil flora? What is the effect of the physical and chemical condition of the soil, on the availability of plant nutrients? These, and many other problems, are open for solutions.

The results accomplished by the Ohio Experiment Station with field crops, and the Rhode Island Experiment Station with vegetables in this country, and the Rothamsted Experiment Station with grain, forage and root crops, are indicative of what may be accomplished at others when it is fully realized that fertilizer experiments are of long duration, and that much time and thought must be exercised in planning them. Short time experiments of this class may have immediate value in the field of demonstration, but they add little or nothing of permanent worth to our knowledge of the subject.

PLANT BREEDING.

Plant breeding is a popular subject for olericultural investigations, as exemplified by the forty-six subjects mentioned under their heading. The object in many cases seems to be to determine lines of inheritance, but in others attempts are made to modify characteristics as a means of adapting the plant to the desired ends. Better progress will undoubtedly be made when the lines of inheritance are definitely established, but in the meantime, much may be accomplished by applying the knowledge we have.

There are a number of varieties of vegetables of excellent local adaptations, but on account of their inability to accommodate themselves to varied conditions, their distribution, and consequently, usefulness, is limited. Here is an opportunity for the plant breeder to modify the old, or to produce new strains and varieties that will meet better the demands. The variety of potatoes now grown as a truck farm crop in the Middle Atlantic States is quite resistant to early blight and tip burn, and the yield is generally good, but the table quality is inferior. Some other varieties are equally as early and the table quality much better, but the foliage is so susceptible to the diseases mentioned that the yield is usually unsatisfactory. A variety with the yielding quality of the one, and the table quality of the other, is desirable. Some of the best varieties of tomatoes and lettuce for the home garden are not desirable for commercial

growers, because they will not withstand the vicissitudes of transportation. But probably the most attractive division of the entire field for the olericulturist is the development of disease and insect resistant strains. The recent progress in the production of strains of cabbage resistant to yellows, and tomatoes resistant to wilt, are indicative of what the future has in store for the faithful investigator.

STORAGE AND MARKETING PROBLEMS.

Storage and marketing problems, always of economic importance, are especially apropos at this time.

Studies of methods in handling and packing, in order that the produce may reach its destination in good condition, are important. These should include effects of maturity, and methods of packing on marketing qualities. Much valuable work has been done on methods and effects of pre-cooling at loading station, and refrigeration in transit, but there are many phases of these problems yet unsolved.

It is feared that even our horticultural leaders have not fully appreciated the need for authentic information on the disposal and utilization of waste and by-products. The canning industries are asking for methods of economical use of waste materials. A recent bulletin of the United States Department of Agriculture on utilization of waste tomato seeds and skins illustrates the point in question. The extraordinary demand for stock foods and industrial alcohol are stimulating the canners of sweet potatoes, pumpkins and other vegetables, to demand assistance in their lines. The rapid development of the girls' canning club movement serves but to direct attention to the possibilities of dehydration as a means of food conservation. The progress made in the utilization of peanuts as a staple source of food has elevated the humble goober from the street vendor's cart to a position of prominence among the staple products. It is frequently served in the form of peanut butter, or a substitute for the better grade of olive oil. The progress in the utilization of the soy bean in the arts, in the production of stock foods, and even in the production of pork and beans and other culinary products, is of international importance.

A study of the factors limiting the economical production and marketing of vegetables and vegetable products is important. Why has the industry developed in certain localities and not in others? There are undoubtedly reasons why vegetable production has reached such high state of development in Florida, Virginia and New Jersey, and not in the intervening states; why Astabula, Cleveland and Boston are centers of greenhouse vegetable production, and Pittsburg, Philadelphia and New York are not. These, and many similar problems of lessor magnitude, are awaiting solution.

PHYSIOLOGICAL AND BIOCHEMICAL STUDIES.

There is a long recognized demand for more and for specific information on physiological and biochemical phases of olericulture. What are the factors causing deterioration in varieties of potatoes? Why do ap-

parently healthy tubers of some varieties grown in the northern potato belt, produce plants affected with mosaic, or leaf curl, when planted for two or three generations in Bermuda or in the Southern States, while others retain their vigor for a number of years? What are the factors underlying the practice of using northern grown Irish Cobbler seed tubers for producing the early crop in the trucking regions of the Southern States; but for maximum yields, locally grown seed produced in the late fall from northern seed of the previous year's harvest? What physical and chemical changes occur in cabbage plants affected with "yellow?" What are the chemistry and physiology of mosaic diseases? The solution of these, and many other problems, will undoubtedly modify our cultural practices.

INSECT AND PLANT DISEASE STUDIES.

The study of insect and plant disease control is so closely associated with horticultural practices that it is thought best to mention them here. The campaign now being waged for the eradication of the cattle tick in the Southern States is founded on the established fact that the Texas fever is transmitted from one animal to another by these insects. But we have been slow to recognize the possibility of insects transmitting any form of plant diseases. It is now well established that some of the so-called physiological plant maladies are transmitted in this way. Therefore the control of insects becomes of new importance to the plant culturist.

The study of life histories of both insects and fungi causing plant diseases should undoubtedly be delegated to specialists in those lines, but the application of the remedies has such intimate bearing on the productivity of the plants that the study of the effects of the remedies on both the parasites and host plants should be considered from the horticultural viewpoint.

There is evidently much yet to be learned about various cultural practices and their influences on disease and insect infestations. What rotation should be followed to eliminate "bacterial wilt" or nematode worms from our garden soils? What are the best methods of soil sterilization for both greenhouse and field conditions? These and similar questions, are being asked by the practical grower who believes he has a right to demand an answer.

The importance of this class of work may be fully appreciated when it is remembered that of the 285 studies mentioned in the list cited, 102 were of this character.

MISCELLANEOUS STUDIES.

There were a number of miscellaneous studies mentioned, including such topics as irrigation, effects of locality on plant growth, influence of high altitudes, inter-cropping and vegetable seed production. All of these are of economic and scientific importance, but time forbids discussing them here.

This brings us to another phase of the subject which is worthy of consideration; that is, the institutional experiment. It is evident that several phases of the work mentioned can, and should, be conducted by the horticultural department alone; but, for satisfactory solution of others it is necessary to elicit the aid of specialists in the respective lines. These should be under the direction of the head of the department, or the man in direct charge of the experiment, and be responsible to him rather than to heads of other departments in the institution. This would enable him to marshal all his forces, and to attack the problem from the various angles. The responsibility for results would then be centralized in one man, or department, rather than in many. Several horticultural departments now have specialists in various phases of fruit, flower and vegetable investigations, including physiological and chemical studies. Hence, it seems consistent to hope and expect the better organized departments will carry on their regular force specialists in soils, biochemistry, pathology, entomology and other allied subjects.

THE PLANNING OF AN EXPERIMENT FOR THE FERTILIZATION OF VEGETABLES.

By C. E. MYERS, *Pennsylvania State College, State College, Pa.*

Last year at the meeting of this society there was considerable discussion concerning the subject of the planning of an experiment. The discussion indicated that the subject is one of vital importance to many of us workers in this field of science. It also indicated that frequently, experimental projects are instituted without having been properly planned.

Within the past two years we have given considerable attention to the planning of a project at the Pennsylvania State College, to secure information on the fertilization of vegetables.

Persons concerned in the work of vegetable gardening have long appreciated the lack of definite knowledge with respect to the fertilization of the more important truck crops, while at the same time they fully realize that immense sums of money are spent annually by persons engaged in the production of vegetables.

From the nature of the work it is obvious that a project of this kind, to be the most valuable, must be planned to consider several phases of the subject, yet, each phase should be inseparably associated with another so that when the data are studied and conclusions reached, it may be possible to determine the limiting factors in the point concerned. At the same time the project should be so planned that it may be continued for a long period of years, thus eliminating, to a large extent, differences due to seasonal conditions.

At the beginning of the consideration of the project a study was made of the available literature on the subject, in order that in-so-

far as possible, duplication of the work of others might be eliminated, and when features were observed that were considered desirable they were noted and when practicable incorporated in the project. Furthermore, for the purpose of securing suggestions and criticisms from workers in fields of agricultural science, other than vegetable gardening, conferences were held with agronomists, agricultural chemists, soil physicists, pomologists, and others, and finally before the project was adopted, it was thoroughly discussed by the research staff of the institution, after which, when the desired changes were made it was approved. Thus it may be truthfully said:

"I have gathered a bouquet of other men's flowers and only the thread that binds them is mine own."

The three crops which we decided to study are early cabbage, early potatoes, and tomatoes, grown in a four year rotation with timothy and clover completing the fourth year of the rotation. The land chosen was a part of a general farm which has recently come into the possession of the College. From general appearances the soil seems to be quite uniform. The field was laid off into four sections, to permit of the four-year rotation, each section comprising about one and three-fourth acres. (See illustration.) Each of the sections is treated as a unit and is further subdivided for the purpose of the experiment.

In order to determine, as accurately as possible, the original character of the soil, a record was kept of the yield of the hay (mixed timothy and clover) the year previous to the beginning of the treatment on the respective sections. The section is laid off into the small plots as is shown in the main part of the plan, and a study made of the uniformity of the stand as well as of the record of the air dry weight. In addition, samples taken of both the soil and subsoil on each of the one-hundredth acre plots, to be used for future study and comparison.

The project was established for the purpose of securing information on the following points:

1. What element of plant food is most necessary in the profitable production of each of the crops mentioned?

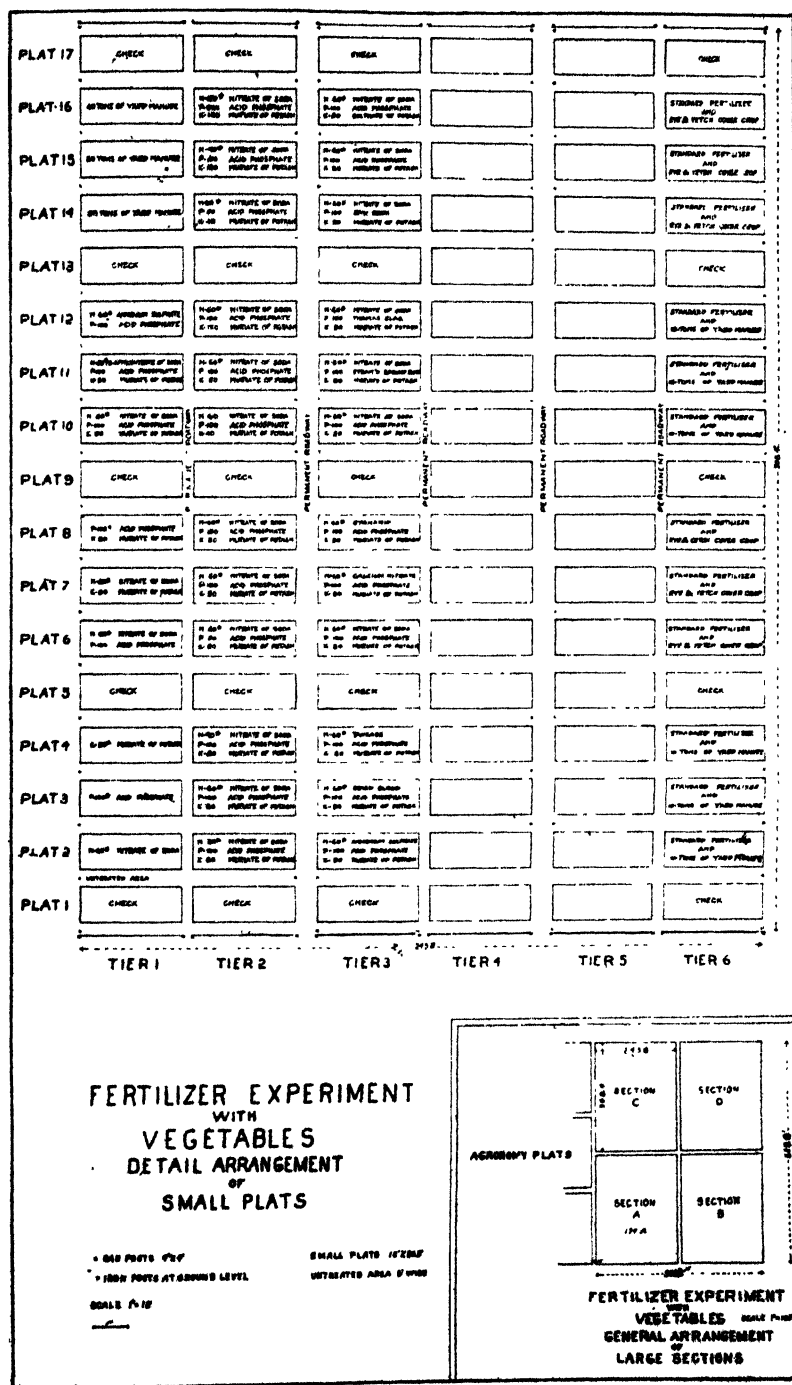
- *2. What is the optimum amount of these elements to apply?

3. What is the best carrier of the respective elements?

4. What is the relative value, following the truck chop, of a cover crop grown through the winter and plowed under, as compared with an application of ten tons of barnyard manure, for maintaining the humus content of the soil?

In order to study these questions, it was decided to arrange a series of plots, each of which was designed for the study of a particular phase of the subject. Thus each of the four large sections was divided into six tiers which are treated as a unit with respect to the purpose for which they were established, and are plowed as such. Thus Tier 1 is designed to give information on the first question; Tier 2 on the second, Tier 3 on the third. Tier 4 is a duplicate of the first tier, with the order

* The Standard application of fertilizer, namely: 60 pounds of nitrogen, 100 pounds of phosphoric acid, and 60 pounds of potash, was adapted as most nearly representing the average of the general practice in the fertilization of these crops.



of plots reversed, and Tier 5 is a duplicate of the second tier, also with the order of the plots reversed. The sixth tier is designated to give information on the fourth question.

Each tier is separated from the adjoining one by a permanent boundary four or eight feet wide as the case may be. This makes them readily accesible, yet serves to maintain the individuality of each.

The unit of treatment is the small rectangular plot 12 by 36.3 feet in size, and comprises one one-hundredth of an acre. We consider these plots sufficiently large to give a fair measure of accuracy in the study of the treatment of the crops concerned, and at the same time the size is convenient for making computations. Each plot is separated from the adjoining one by an untreated area six feet wide, although this area is planted the same time as that which is treated, but no record is kept of the yield from it. For the purpose of determining lack of uniformity in the soil every fourth plot is designated as a check or untreated, and when yields are computed, corrections will be made for the indicated differences.

Thus far, only one crop has been grown. During the past season early cabbage was grown on Section A, and while it is much too early to make predictions as to what the value of the project may be, it indicates that it may probably be the means of giving some interesting information on subjects which are at present puzzling the scientists as well as the commercial farmer.

PLANNING AN EXPERIMENTAL PROJECT.

By W. L. HOWARD, *University Farm School, Davis, California.*

Planning an experimental project is like getting ready for an exploring expedition or for a war movement. Just as Joshua of old is said to have encircled the walls of Jerico several times before attacking that stronghold, so must the modern agricultural investigator, figuratively at least, go round and round his problem before maturing his plans and launching his attack. The problem itself may be as plainly evident as the Mississippi river was to DeSoto, but what about its beginning and end, that is, where does it start from and where does it lead to? DeSoto very much wanted to know these things in connection with the great river he had discovered, and so does every other explorer or investigator face just such questions.

Approaching his problem, then—to pursue further the simile of discovering the Mississippi—shall the explorer first go upstream and search out its source, then back-track and explore down to its mouth, or, shall he divide his forces and try to do both at the same time? Suppose he decides to go upstream, beginning at the point where the river was first discovered. All goes well at first because the majestic stream is easy to follow, but by and by he comes to the outlet of the Ohio and there is some hesitation as to which is the main stream and which the tributary. A brief examination, however, shows that the stream he has been follow-

ing is much muddier than the tributary and, while the eastern branch looks interesting—enough so to warrant following for a few days—he decides to pass it by and continue northward on his mission. At length he reaches the mighty Missouri river and this is not only very muddy, but so near the same size as the other that he is indeed in trouble to decide which one to follow. When at length he has decided which he thinks is the Mississippi and proceeds to follow it, he does so with grave doubts as to whether he may not, after all, be pursuing the wrong course. In other words, while his problem is still well defined, he finds it has many interesting and important ramifications and long before he has gone to the bottom of the main question, or reached the source of his river, he actually comes to a place where there appears to be two rivers, or problems, instead of one. What is to be done? The answer is that it is wholly a matter of individual judgment and that every dilemma of this kind must be decided on its own merits. Some will choose to follow the big muddy stream from the westward because the stream that we have been following up to this time was muddy, while our explorer, on the other hand, will discern the true stream and elect to follow it up and up, past the Illinois, the Des Moines and Wisconsin rivers and other rivers, over the rapids at Keokuk, past the falls of St. Anthony, and on to Lake Itaska or to the very source of his problem he has been pursuing, having refused time and again to be attracted or diverted from his course.

The illustration is intended to show that it may be easy enough to pursue a question, if we can always keep clearly before us just what the real question is and not be deceived or lured away by the numerous Lorelei and camouflage issues that have the habit of showing up along the way.

It is evident from the foregoing that the investigator, like the architect or railroad builder must have a plan or project outline so that he may have a clear notion of what his problem is and how he plans to attack it. Such a plan may help to keep him from being side-tracked or led into a blind alley, but no piece of research worthy of the name can be so outlined as to eliminate dangerous ramifications from developing, for these are only encountered after the work is well under way, and moreover, they are good evidence that progress is being made. But there will come times when it will require resolution and a clear head to resist the impulse to leave the main issue in order to follow a prominent or promising tributary.

Our project outline completed, we must determine the logical points of attack. These may or may not be easy to decide. The main questions to consider will be, first, to determine what the important points are, that is, whether to plunge into the work at the initial place that offers an opening, or to start in such a way as to head for the source, beginning or foundation; in other words, to strike at fundamentals. For example, in making a study of fruit bud development and differentiation it has been found best to begin with the normal or fully developed bud and work back to the abnormal or undeveloped condition. On the other hand, in studying the pollination of fruits, results would be much delayed if one first undertook to work out all of the physiological ques-

tions that underlie self-fertility and self-sterility before making actual field tests to determine what varieties really set fruit from their own pollen or from the pollen of other varieties. Sometimes it is better to begin at one end of the river to be explored and sometimes at the other, and even sometimes in the middle, or wherever one happens to encounter the stream.

Getting down to cases let us briefly consider the root-stock question of fruit trees. To every one who hears this question mentioned there immediately comes a mind picture of specific points that need attention first and in the main these will be determined by the region or locality where the person lives and works. Those from the North will perhaps first think of hardiness, resistance to cold; those from the South, resistance or immunity to root insects or diseases; those from the arid regions, ability to live without water and to withstand desiccating winds, and to those from the Pacific Coast, California in particular, all of these and a dozen more on account of climatic conditions ranging from the desert with only a trace of rain, to an annual precipitation of 100 inches, elevations from nearly 300 feet below sea level, to 10,000 feet above; soils from black alkali to silt loams averaging from fifteen to twenty feet deep, temperatures of 100 degrees and over day and night for months, to an annual mean of seventy or less; from the cool, foggy coast to the hot, interior valleys, from absolutely frostless belts to regions covered with from two to twenty feet of snow half the year, and finally, on account of high priced land and the immense monetary value of the fruit industry, all of the things that can be thought of pertaining to root-stocks here or elsewhere are of paramount importance. In order that there may be no misunderstanding, I want to make it clear that fruits are grown in our state under all of the conditions enumerated. Also I want to say, since the discussion is getting to be rather specific and more and more personal, that the time is near when I shall have to outline a definite project providing for a comprehensive root-stock investigation. I have in fact already been called upon by fruit growers to submit such a plan to a special committee consisting of fruit growers, nurserymen and the State Commission of Horticulture. The plan submitted was only a tentative one, was hastily drawn up, and very faulty, but it was something in black and white and was welcomed by every member of the committee like a long lost brother. Our growers and nurserymen, as well as the State Commission, are insistent that something be done, but we are holding off until better facilities are provided. However, we may be compelled to make a start with what facilities we have.

We are confronted by the following questions:

1. Shall we set apart a few acres and immediately begin propagating trees of different species and varieties on different stocks when we do not have enough land to grow them to maturity?
2. Shall we wait a couple of years or so when we shall probably have the land and can start experiments that will not be disturbed?
3. Shall we at once take up a botanical and historical study of the different stocks and laboratory studies of graft unions and also start a survey of facts and conditions in the State?

4. Shall we call upon the Bureau of Plant Industry to round up all possible or promising stocks for different purposes and start a collection of them?

5. In short, should we try to do anything with this investigation now when we could not possibly carry out a comprehensive plan, or should we wait a bit until the whole problem can be assigned to a competent man with proper facilities given him to tackle the problem, perhaps at different points at the same time and to do whatever he does thoroughly?

We have been inclined to take the latter course. To start some detail now might do little good on the whole, even though we had a general plan, as such a procedure might be likened to starting the construction of a house—with an architect's plan in hand, without having enough stone or cement for the foundation, or enough shingles for the roof, but with a miscellaneous collection of lumber that might be used for various purposes about the building.

As I see it for California conditions, the root-stock problem consists of at least three rather distinct parts, although each is dependent upon the other.

1. There is the survey feature and historical part of the stock question. Under this might be included a systematic inquiry into present conditions in the state whereby the experience of nurserymen and growers would be revealed. Under the historical part it might be necessary to send a special agent to foreign lands to study the different species commonly used for stock in their native habitat, and present world conditions are not favorable for that. This part of the investigation might best be carried out in cooperation with the Bureau of Plant Industry.

2. The actual preparation of the different stocks for testing would really be a nursery job as it would be necessary to propagate thousands of trees of known varieties on known stocks, for we would want to include almonds, apples, apricots, cherries, peaches, pears, plums, prunes, and walnuts with all the principal varieties of each.

3. The final phase or part of the investigation would consist of testing the trees. And right here one of the most serious problems presents itself, which is, how are we to judge the value of the different stocks? There are two things in particular that we want to know: First, the success of the graft union as regards the strength, longevity and fruitfulness of the trees; and, second, the extent to which the different stocks may adapt the trees to special conditions of soil, climate and root parasites.

Obviously only a part of these questions could be answered by planting all the trees at one place, under one set of conditions. According to our conception of the problem, though, at least a few of all the trees should be planted side by side in one place and be kept under observation for an indefinite time. In addition it would be equally necessary to send collections of certain trees to be planted and grown under some of the special conditions as on the coast, in the coast valleys, in the hot interior valleys, in the desert and semi-desert, in the humid regions on the western slope of the coastal mountains, in the foothills of the

Sierras and Coast Range, and in the high mountains. This would have to be done under some sort of leasing arrangement. Fortunately under our laws the University can lease land for a period of fifteen years. Such a test would give us much valuable data and perhaps best of all, would have a tendency to give the growers more confidence in the results.

Such in brief are our ideas and plans for one line of investigation which we hope to get under way in the near future and it might be added that the fruit growers in three or four of the big associations with an aggregate annual output valued at many millions of dollars, are now actively at work on plans for demanding of the next legislature that a deciduous fruit experiment station and graduate school of pomology be established with an initial appropriation of not less than \$250,000 in order that we may investigate the root-stock question and the many, many other fruit questions that are pressing for attention. And we will get it, too, if the world war does not actually reduce the state and whole country to a condition of abject poverty, for, if there is one thing the average Californian likes better than a big proposition, it is a still bigger one, the little ones do not interest him at all.

REPORT OF THE COMMITTEE ON RESEARCH AND EXPERIMENTATION.

By H. J. WEBBER, *Chairman, Citrus Experiment Station, Riverside, Cal.*

The Committee on Research and Experimentation in Horticulture have been unable to have a regular meeting together in order to discuss and submit a joint report, and for this reason it has been thought best to submit separate discussions from each member of the committee. We are thus submitting as the report of the committee the following papers:

"Suggestions on Research Problems," by Dean R. L. Watts, of Pennsylvania State College.

"Report of the Experimental Work in Floriculture," by Professor A. C. Beal, of Cornell University; and,

"The Stimulation of Research," by Doctor H. J. Webber, Director of the Citrus Experiment Station, University of California.

THE STIMULATION OF RESEARCH.

By H. J. WEBBER.

The work of the Committee on Research and Experimentation, it appeals to the writer, should be directed: (1) toward extending research; (2) toward the introduction of better methods; (3) toward the co-ordination and systematizing of research work. It is my purpose to discuss briefly the first of these headings; namely, extending research.

Why should we be interested particularly at this time in extending our research work, when we are faced by the greatest crisis in our history, and the world is demanding of us a larger production of food-stuffs than ever before? This, it may be replied, is the primary reason for more extended investigation. The two ways of increasing our output are: (1) by growing a larger acreage; and (2) by increasing the yield per acre. If we attempt to increase the acreage tilled, without a doubt a larger labor supply will be necessary, because the majority of farmers in the past have worked about to the limit of endurance and can only slightly increase their output with the same force of labor available. It seems doubtful whether we can increase the supply of farm labor, when several millions of our young men are being taken away for army service. It seems more reasonable to the writer to expect that our greatest increase in production will come about through the use of better scientific methods and more intensive farming of the acreage available. As an illustration, the use of more and better manures, or the use of better seed, results in a greatly increased yield with the expenditure of but little extra labor.

Up to the present time, the tendency of our agricultural institutions in meeting the war emergency has not been to increase the investigational work, but to increase greatly what we usually designate as extension work. This we shall probably all agree has been a wise action, but it is creating a new situation where increased investigational activity is greatly needed and will doubtless soon be demanded.

The demand for increased production has led to a great development, under the Food Production Act, of the farm bureau system. A farm bureau with a farm agent in every county of every state has become nearly a reality. This is an agency largely intended to carry agricultural education to the farmer on his farm. The farm bureau system as I have observed it, is carried on in an intensive way, with the agents working at high speed under pressure. The organization campaign stimulates interest and gets the farmer to thinking. He begins to realize that there are many things he doesn't know. He comes to the farm bureau meeting for an explanation of his problems. The county farm agent, however able a man he may be, is certain to be confronted with very many questions that he cannot answer—many indeed that no expert in any department can answer. To be successful he seeks answers for these questions from the specialists of the experiment stations and the United States Department of Agriculture. But a considerable number of problems put before him cannot be answered with any positive information, and he is likely to be led into hazarding a guess, which he substitutes for real information. This will react on the agent who is likely to blame the research men for not being able to give him the desired information.

A few minutes of study given to the present development of agricultural activity is sufficient to enable the investigator to realize that he is facing a crisis. I fear that few of us concerned in agricultural research realize how serious this crisis is.

The war has led to an intensifying of the demand for scientific knowledge related to agriculture. The nation in its crisis has doubled

and quadrupled the men who are expected to teach agricultural science, but this has been at the sacrifice of those charged with the discovery of scientific truth. No provision has been made to increase the number of agricultural investigators, but if anything the number of investigators has been decreased.

It may be claimed that the discovery of new scientific facts regarding agriculture would require too long a period of time to be of service during the war. This may or may not be the case, but it in no way alters the condition. We are stirring up a tremendous demand for information and providing a tremendous machine for transmitting information without providing in like measure to secure the information to be supplied. To teach, one must have information to impart. It is true that we have a large amount of trustworthy scientific knowledge regarding agriculture, but in general, agricultural practice is pretty well abreast of scientific discovery, and this is particularly true in the field of horticulture. The county farm agent or farm adviser will certainly assist very greatly in extending the knowledge of scientific agriculture, but he will not be able ordinarily to add anything to our body of knowledge.

The immediate effect of the great extension of the farm bureau system will be to detract from the public recognition given the agricultural investigator. The public is likely to form the impression that the farm bureau and the county farm agents are the final authorities and that what the farmers get from them is all that can be expected. The farm agents are the "men on the job." They are the ones that hand out the information. Of what use is it to maintain a costly experiment station, when the men do not seem to do anything, or at least do not get around to give the information they are supposed to have, and when they do attempt to give information seem to be so doubtful about it that what they say has no point.

The investigator is the man who will discover the new agricultural principles. That is his business, and he succeeds or fails dependent upon whether he has the ability to discover new facts and principles, and properly correlate them. It is to him that the county farm agents and extension agents the country over must look for new methods and new principles, the introduction of which will improve agriculture. The farm agent may find a plant disease that is doing much damage in his section, but he is not supplied with the facilities to conduct an investigation as to the cause and method of treatment of the disease. A new forage plant may be introduced into a section, the value of which in feeding, should be determined. The farm agent must turn to the investigator to conduct the feeding and digestion experiments with the plant. Some intricate problem of fertilization may arise that requires a careful investigation, and only men with the proper training and time at their disposal are in position to seek a solution of the problem. Our exact agricultural knowledge is still so fragmentary that hosts of problems are every day brought to the attention of our agricultural men that cannot be answered on the basis of any exact knowledge. These should not be answered by guesses. If any one is to do the guessing, it is better that the farmer himself should be the one.

How are we to succeed in getting this great mass of investigational work that is demanded, done? The demand is in no one particular branch of agriculture, but equally in agronomy, horticulture, animal husbandry, and all branches of agriculture. Are the present facilities and man power for investigation sufficient to the task? I think this question may be answered very emphatically in the negative. The investigators now employed are overworked and forced to give attention to too large a range of problems to accomplish the best results. It is the general experience of experiment station workers that necessity requires them to give attention to so many problems that the work on any one problem, however important, is interrupted and delayed.

Is there any probability that this condition is likely to be remedied in the near future? To this we must also answer, "No!", unless some new impetus is given to investigation.

Every year in general has shown an increase in the number of students registering for higher degrees in our universities, presumably in preparation for investigational work, but the increase is too slow and present funds are too inadequate to provide properly, in view of the great expansion of the extension service, for the work. What then is the remedy?

The writer realizes that he is not in position to formulate policies for the country, but he can at least make suggestions, and the following are a few thoughts on the subject:

- (1) Investigators and those realizing the necessity for scientific investigation of agricultural problems should use every means to educate the public to an understanding of this necessity, and of the time it takes to conduct the necessary experimental work.

- (2) Every means should be used to establish and maintain a sympathetic relationship between experiment station investigators and the extension and farm bureau agents, based on a thorough and mutual understanding. The two fields of work are entirely distinct but mutually dependent one on the other. Possibly the proper sympathy may not exist in every case.

- (3) Investigation work requires concentrated attention, and the extension and farm bureau service of the various states should be led to appreciate that the greatest service the investigator can achieve for the country and for them is the completion in the quickest possible time of the investigations leading to the solution of the doubtful problems confronting agriculture. This can only be done by conserving the investigator's time. We must of course recognize that common sense methods should be used here as in all cases.

- (4) As to the possibilities of extending agricultural investigation, this can only be done by using increased funds and educating more men in the pursuit of scientific investigation.

- (5) A larger force of trained investigators is the most important problem before us in the writer's opinion, and it is his belief that greater facilities in the shape of scholarships should be provided for the use of young men that desire to fit themselves for investigational work.

- (6) Increased efficiency might result from a more careful coordination of the research work of the various stations. There is some duplication that might be avoided by a careful comparison of projects.

REPORT OF THE EXPERIMENTAL WORK IN FLORICULTURE.

By A. C. BEAL, *Cornell University, Ithaca, N. Y.*

A survey of the field of investigational work in floriculture will reveal the fact that some of the first bulletins of the experiment stations presented the results of work intended for the benefit of the florists; i. e., greenhouse construction and heating, then followed the studies of artificial illuminants and their effect upon greenhouse crops, and finally studies of the effects of anesthetics for shortening the rest period in plants. Twenty years ago, the variety tests and the monographic studies with flowers began. About the same time some fertilizer studies were made. Except for some work by Professor Budd of Iowa, in breeding ornamental plants, such as roses, for the severe climate of the Northwest, little was done in this field until the selection work on violets reported by Dr. Galloway; but more recently some breeding work has been done with greenhouse flowers, particularly with carnations. The foregoing indicates the main lines of floricultural work hitherto undertaken by the experiment stations.

The investigations in floriculture fall into at least two groups; first, the ones intended to solve problems of interest to those who grow flowers in garden or field. Most of these are amateurs, and they are often interested in all of the known types and varieties of a plant. However, some who grow flowers outside grow them for sale either as cut flowers, e. g., asters, sweet peas, etc., or for the bulbs or roots, e. g., cannas, or for either flowers or plants, e. g., gladioli, dahlias and peonies.

Somehow, we fail usually to think that any plant presents its problems unless it is grown commercially, forgetting that many more persons may be interested in successfully growing a flower even though the individual investment is small. If we grow a plant because we love it, that makes us no less keen to succeed with it than if we grew it for revenue. Thus in some of our floricultural work, we should erase the dollar mark and consider the interest of persons in plants as beautiful plants. The number of the outdoor annual and herbaceous flowers is very great. Their range of climatic and soil adaptation is not perfectly known today. Certain species have been improved under the conditions existing in Western Europe, and because they are not adapted to some portions of the United States, we should not despair for often in the same genera may be species from regions more nearly similar to ours which, if taken in hand, may be capable of like improvement. At least it cannot be proved either way until it has been tried. We should be alert to find conditions favorable for the production of any crop which we are annually importing. The man who inaugurates a new industry in his state has rendered a worthy service in line with principles which we have had borne in upon us very thoroughly during the last three or four years.

The second group of floricultural investigations include all investigations carried on under glass. The interest in this work comes from the commercial growers, and the horticulturist needs to know something of the industry these men represent.

Commercial floriculture is a highly specialized, intensive business. Considerable capital is invested in the establishment, and the expenditure for labor and fuel is very large. The florist must of necessity be keenly alive to the demands of the market. Naturally, therefore, the successful florist is a keen business man who is very much alive to any advance in greenhouse building or methods of heating or refrigeration. He annually spends considerable amounts in trying out new varieties or appliances, and it should be said that when he tries out a thing he does so on a considerable scale. By this, I do not mean to say that he is scientific in his methods of testing. In short, the commercial florist has facilities in modern up-to-date houses and other equipment such as few colleges and experiment stations can approximate. Likewise the experimenter may not have the special training to grow flowers or plants as skillfully as the commercial florist. Of course, a florist is more skillful in some crops or plants than in others, and not all growers are alike. Neither can it be expected that a station florist will be equally skillful in growing all commercial plants. This skill must obtain, however, either in himself or in his gardener. It is my thought that if one is attempting to solve any plant-growing problems for the florist, he should grow his plants by an accepted commercial method. If the experimenter does not know such a method, he will not get very far in the esteem of practical men. What will it avail to carry out a nutrition experiment with species of dry plants unless the experimenter at the same time practices the usual methods of potting or benching, pinching, training and supporting the plants? To grow plants by any other method or by no method, introduces variable factors which destroy the value of the experiment in the eyes of the practical man no less than it does the scientific man. Possibly this is so evident to you that you wonder why I speak of it; therefore, it may be well to say that I have seen such grossly improper potting of plants that the work looked like that of some child, and if attempted while in the employ of a florist would be punished by immediate discharge. There comes to mind two cases of reputable men, who, when called in by the growers of an important flower crop, failed to secure the cooperation of the growers after a short time and ultimately failed to solve the difficulties put before them largely because they exhibited at the outset a total lack of knowledge about growing the crop. The plants which they took over for their work were handled by methods so extremely original that the growers were at first amazed, then disgusted and finally gave up the hope of receiving any assistance. A great many greenhouse troubles disappear by proper conditions and sanitation, so when these practical growers saw all accepted rules and practices ignored, thereby bringing in all the difficulties which they themselves had surmounted, they naturally did not want to gain the end by means so vulnerable. It was only a natural result that the institution to which these men belonged has suffered a loss of respect in that locality. I have brought this up because

I see a tendency to belittle the importance of a knowledge of practical methods. So far as my observation goes, it is better for the scientific man who has not thus prepared himself to remain in his laboratory and not undertake cooperative or other experiments in the greenhouses of practical growers, for it is difficult to find a more critical body of men than florists and gardeners.

Certain types of experiments are barred at the outset unless one has suitable greenhouse equipment which will give the experimenter as near as possible commercial greenhouse conditions. Unless the equipment and skill approximate those of the practical florist, the results are not likely to impress him or will not be reliable under his conditions. (To attempt such investigations, therefore, is likely to be wasted effort.) This applies particularly to all experiments in which yield is used as a measure or index of the value or effort or a given treatment as is usual in experiments with cut-flower crops. For soil and fertilizer investigations with these crops, it is rarely possible to carry out a well planned experiment in a house less than 20 or 24x100 feet or larger. if one plans to include within each plot a reasonable number of plants so as to lessen the effect on individual variation. Check plots must be distributed so that differences of temperature, etc., within the house may be checked up. Plants on exposed ends of the benches, as well as plants on side benches, cannot be compared with center benches. The heating pipes must be properly distributed to secure as even conditions as possible throughout the house.

To carry out soil and fertilizer trials with pot plants not so elaborate houses are required, provided the temperature and other conditions can be well regulated and the house is adapted to the kind of plant grown. Here is an important as well as an inviting field of work. The whole fertilizer question is an important one to the florist since he has always been a firm believer in barnyard manure. The constantly increasing difficulty of securing this fertilizer with the result that the florist and gardener must resort more and more to commercial fertilizers about which he knows little as to their use, opens up a wide field of investigation. When one is growing plants in four or five inches of soil under artificial conditions, the applications of easily soluble fertilizers cannot be governed by rules formulated upon experience derived from the use of the same fertilizers under outdoor conditions. The presence of plenty of organic matter appears at least to be imperative. How to supply the requisite soil conditions and to lay down safe rules as to application of the commercial fertilizers, is a line of work now pressing for solution. There are a great many kinds of greenhouse plants so that there is work for many men. In fact, more work on this line than the men with sufficient skill and equipment can accomplish in many years.

Work for the florist, therefore, will have to be of an advanced character. It is doubtful if greenhouse practices, so far as increased production is concerned, can be modified very much. At least fertilizer experiments thus far carried on do not point to any marked increase in production.

Colleges and stations cannot conduct variety tests to determine the value of flowers for commercial culture under glass. So many questions enter into the correct estimate of a new carnation which the college man cannot properly weigh, that his opinion is not worth much to the practical grower. However, if the number of plants tested were more nearly equal to that used by the commercial grower, and if they were grown by a competent man under conditions similar to those existing in commercial houses, there is no reason why the test should not be as valuable, to say the least, as that of the individual grower. Since a considerable expense, as well as a large amount of greenhouse space, would be involved, this line of work is not likely to receive much attention, nor is it so very important because it is so well done by the practical grower.

Considering another phase of work, you may reply that fertilizer tests may also be left with the grower. To some extent this may be true, but frequently the deductions of the practical growers are quite erroneous. Every wide-awake grower realizes that there is much he would like to know that he had not time to find out for himself, even though he had the scientific training to carry out such investigations. Because the soil used in a greenhouse is a more or less artificial mixture, there is an almost unlimited field for fundamental nutrition investigations with plants. The ability to control the temperature and humidity of the air surrounding the plants, together with the control of moisture in the soil, would seem to make this line of work not only of very great importance to the florist, but also throw light on other nutrition questions. Carefully planned experiments, preferably with the advice of the soil technologist, should, it seems to me, not only answer the questions of the practical man, but also yield data which, if properly gathered and set forth, would be extremely interesting to the soil and fertilizer experts.

Flowers have been much hybridized so that they do not offer good material for breeding experiments to discover underlying principles. However, there is a good opportunity for some work if one selects the plants that have not been cultivated for so long a time or if he recognizes the limitations of the material he is working with. Studies in selection are being carried on and doubtless other valuable work can yet be done.

The present experimental activities in the floricultural field, as they can be judged from the list of projects reported in our proceedings last year, may be clarified under five heads; the experimental work falls into four groups:

1. Soil and fertilizer experiments with flower crops or plants.
2. Breeding and selection work.
3. Monographic studies with flowers including variety studies of outdoor flowers.
4. Scientific investigations with either and the factors influencing the keeping qualities of flowers.
5. Plant adaptation studies for the purpose of establishing new industries, e. g., bulb growing on the Pacific Coast, etc.

I have tried to point out the importance of good equipment, of sound practical knowledge, that it is better to refrain from tests which the florist can do much better for himself, and that there is an almost unlimited field of work from which, always considering the limitations, a satisfactory choice can be made.

REPORT OF THE COMMITTEE ON RESEARCH AND EXPERIMENTATION.

By R. L. WATTS, *Pennsylvania State College, State College, Pa.*

All of the resources of the United States will be required to win the war. The food problem becomes more serious every day, and it is the duty and privilege of the experiment stations to undertake lines of investigation which have a direct bearing upon increased production. The burden of the vegetable growers is especially heavy, and we have this class of horticulturists in mind in making the following suggestions, all of which might be regarded as war emergency propositions:

(1) The plant food problem is a difficult one for most growers. They are in the dark concerning both kinds and amounts of fertilizers that should be applied to obtain the largest and most economical yields. It is astounding how little systematic work has been done along this line by our experiment stations. Numerous simple tests might be cited, but our records for the most part do not show that fertilizer investigations with vegetables have been undertaken on a large, comprehensive scale. A station worker here and there has probably discovered that certain combinations of fertilizers give the best results on certain soil types. The fact remains, however, that we know very little concerning the actual food requirement of most of our vegetable crops. There is urgent need of strong, comprehensive research to determine crop requirements rather than the needs of particular soil types, though the latter type of work is also necessary.

(2) Millions of dollars are lost annually in the vegetable gardens of the United States because of the ravages of fungous and insect enemies. While considerable work has been done relating to the control of various pests, yet we lack knowledge concerning some of the most fundamental matters in this connection. It appears that investigations made along these lines for fruit growers have been more thorough and extensive. Club root of cabbage and other brassica has been known since the earliest days of gardening in this country, and yet we cannot point to the results of any experiments which have really solved this great problem. Other examples might be cited to indicate the great importance of more research work relating to the control of garden crop pests.

(3) It is astounding how much inferior produce annually finds its way to market. Recently, I spent an hour on a typical curb market and it is no exaggeration to say that 90 per cent of the vegetables was of an inferior class. No doubt improper methods of cultivation and mar-

keting had a great deal to do with the inferiority of the produce displayed for sale, and yet we are confident that much of the trouble was due to the use of poorly bred seed. Perhaps this is more of an extension proposition than an experimental project. There can be no question, however, about the importance of our market gardeners planting better seed. The commercial seed growers are accomplishing a great deal in improving strains of standard varieties, but if the experiment stations can do anything in a practical way to help in this movement, it will be exceedingly valuable as a war emergency measure. In other words, there should be more practical plant breeding in progress at the experiment stations as well as among intelligent practical growers.

(4) The supply of meat and livestock products will decrease as the war continues. The protein problem looms high these days when meatless meals and meatless days are being urged for every home, restaurant and hotel. The vegetable growers of the country must do more to increase the supply of protein foods if the meatless campaign is to prove successful. Our experiment stations should give careful attention to the cultivation of the two important garden legumes, beans and peas. Both of these crops offer splendid opportunities for experimentation. We ought to know more about their fertilizer needs, soil adaptation of the different classes, and the best and most economical means of controlling the various pests.

(5) The experiment stations have made practically no investigations concerning the efficient utilization of labor. Probably at no time in the history of the world has so high a value been placed upon manual labor. The large food production program of the government calls for the most intelligent and efficient utilization of farm labor. This proposition affords a fruitful field for study. It is possible that gardening mechanics would not appeal to very many of our horticulturists, but there is no question about the importance of the work. There is urgent need of a wider range of labor-saving tools for vegetable gardening and for more definite information on garden management. We hear much these days about farm management—which in its broadest sense includes garden management—but the whole problem of the efficient use of labor in producing vegetable crops deserves the study of scores of horticulturists. It is a practical line of investigation which would attract much attention and, properly handled, yield results of great value at this critical time.

REPORT OF COMMITTEE ON VARIETY TESTING.

By J. H. GOURLEY, *Experiment Station, Durham, N. H.*

At the last annual meeting of our society some time was devoted to the question of variety testing of the various groups of horticultural plants, and splendid papers were presented which showed what has been accomplished by this work and outlined the methods employed, and gave suggestions as to forms to be used in making such records with fruits and vegetables. From the standpoint of pomology the work reported from

the several experimental farms in the Dominion of Canada can long remain as a guide and inspiration for others who wish to carry on careful work in testing varieties of fruit.

The discussion which followed these papers brought out a difference of opinion as to the value and advisability of the variety orchard in station and college work. This is a serious problem from an administrative standpoint since funds must be available for such work and in more than one quarter it seems almost impossible to undertake extensive variety work owing to the financial element involved. It is well known that such work is not looked upon favorably by the Office of Experiment Stations, and hence any considerable fund for the work must come from the state or other sources. It therefore behooves us to take the matter up in a serious way and canvas the situation to see how the problem can be handled.

Despite criticism from without we still maintain that a knowledge of varieties is of utmost importance and that if we maintain and raise the standards of fifty years ago we must make an extensive and most painstaking study of varietal characteristics and behavior and so record them in a standard and systematic manner that the results are available to all interested persons. If it is true, and I believe a survey will establish it, that we have fewer real amateurs, who formerly did this work, than we had a quarter or half century ago, then the task of carrying on this work devolves on the professional horticulturists of the country. Furthermore, it is a passion or at least a real pleasure to most pomologists to work with and study varieties, so much so that we have often been accused of showing a weakness in this direction and even that some have done little else. But to me it has a great deal of justification and we should be judged generously in the matter for I am afraid that if there were as many breeds of live stock as there are varieties of apples the animal husbandmen would also indulge their passion of knowing the breeds even to the point of wasting time in the indulgence. Again, we have doubtless all had the experience of winning the confidence of orchardists more by knowing varieties than by any information we could give them. However, aside from this mere recognizing varieties by name, variety testing has a much more fundamental and important significance than it has ever had before and we are glad to report that the investigation made brings this out most fully.

In order to learn the present status of variety testing in the country an effort has been made to get in touch with the ideas of all men working in this field. The present report does not deal with methods to be employed in testing varieties of fruit, nor has any attempt been made to bring together and standardize forms to be used in variety testing although such information would doubtless be of value to our members. But the principal objects in the minds of the committees have been to learn the policy of the several experiment stations and colleges on this matter and get the views held by the horticulturists in charge; also to try and locate any variety orchards of special merit owned or controlled by amateurs, commercial orchardists or nurserymen in order to list them for the possible benefit of our members.

With these objects in view the following letter was sent out with a questionnaire enclosed, to each experiment station and agricultural college in the United States and to our members in Canada. The prompt and full response which this questionnaire has met is encouraging to the committee and indicates a lively interest rather than lethargy in regard to this matter.

"Dear Sir:

"The problems of maintaining a variety orchard at the experiment stations and colleges is one of considerable difficulty in many places. Such an orchard involves considerable overhead expense and is often not well adapted to carrying on other experiments so that funds are not available for the work. Since there is a growing spirit of closer relationship between institutions it would seem well to have available a list of places where variety orchards are maintained and thus give sister institutions, especially neighboring institutions, the benefit of the knowledge of variety behavior in any given region.

"With this idea in mind the following questionnaire is prepared in the hope of placing in available form information which will be of inestimable value to all horticulturists within the range of our society. It will, of course, be understood that the policy of the institution in regard to variety testing may not necessarily represent the wishes of the horticulturists in charge, but rather be due to available funds."

Perhaps the most concise way to present the findings of this committee would be to take up the questionnaire and report a summary of the answers obtained from the members of the society and from others on this matter of the status of variety testing in this country at the present time. Occasionally, the answer to one or more of the questions from a report does not appear in the tabulation because it was not possible to determine the exact feeling of the individual on that particular question or questions or else no reply was given. In most cases, however, the answers were clear and contained the information sought.

QUESTIONNAIRE.

1. Approximately how many varieties of the various kinds of fruit do you grow?

The replies indicated that most stations and colleges are well supplied with this kind of material. In case of the large figures reported it indicates that a large number of seedlings are included.

The replies as tabulated bring out the following facts:

<i>Station or College</i>	<i>No. of Varieties</i>
5 report	Less than 50
3 "	50— 100
5 "	100— 150
4 "	150— 200
7 "	200— 300
3 "	300— 400
6 "	400— 500
4 "	500—1000
4 "	2000—3000
1 "	3000—4000

Of these total varieties of fruits the preponderance was:

Apples in 29 cases or 64 per cent.

Peaches 6 "

Pears 4 "

Grapes 3 "

Plums 1 "

Persimmons 1 "

Citrus 1 "

Nuts not indicated.

2. In what fruits are you especially interested?

This question indicates a greater variety of interest at the present time than would be interpreted from the above figures and brought out the following replies:

<i>Number</i>	<i>Greatest Interest In</i>
15	Apples and peaches
7	Apples
4	Apples and plums
3	Citrus
2	Pears
2	Apple and small fruits
1 each of the following:	—Apple and grapes; apple and pears; peach; peach and small fruits; grapes; nuts; peach; grapes; persimmons.

3. Is it the policy of your institution to maintain a large collection of varieties of the tree fruits for variety testing?

This question brought out replies that indicated very clearly a vision of policy on the main question involved since the vote was a draw.

<i>Yes</i>	<i>No</i>	<i>Indefinite</i>
21	20	2

From an examination of the projects listed in our last annual report it showed about 60 per cent of the stations were carrying on one or more projects on variety testing which is in about the proportion indicated by replies to this questionnaire.

4. Do you contemplate extending the plantings of varieties in the near future?

To this question 30 report that they expect to increase plantings in a moderate way and 6 in an extensive way, while others have recently planted extensive orchards. Some reported that formerly they had planted extensive variety orchards and are now systematically reducing them.

5. Do you think every college or station should maintain a large collection of varieties and why?

While this question would appear to be a repetition of Question 3, it was designed to draw out the opinions of the horticulturists in charge at the present time whose judgment may differ from the policy which is or has been followed by the institution. The answers to this question are perhaps as full of interest and express stronger personal feeling than

any other in the list and as might be predicted from the replies to question 3 the vote is again a tie, 18 voting yes with much emphasis and 19 voting no, after having apparently given it equal consideration. Those voting in favor of it gave as their reasons that it greatly aided instructional work and most of them had in mind a careful study of variety behavior in order to make clear what material to use in hybridizing to improve varieties or for some other reason relating to research work. The extent to which variety orchards are used for the latter is illuminating. Of those of contrary opinion 6 stated that it was too expensive for the benefits derived, 3 thought that the usefulness of such an orchard was doubtful owing to the lack of uniform behavior of varieties throughout a region, especially in Western states this feeling was strong. Two seemed to think it represented useless duplication while 8 thought it was much better to keep in close touch with successful growers throughout the region in which the institution is located. They would plan to have varieties sent in by the growers for instructional work as well as for other purposes and thus obviate the necessity of such an orchard. However, in regard to this matter two make the pertinent suggestion that reports from growers are of doubtful value because they may report on a variety which is not true to name and would therefore have to be checked up before any record of behavior could be accepted. Professor W. J. Green, of Ohio, makes the following pertinent remark in regard to the matter: "The point I take is that no study or comparison of varieties is of any value unless it is known positively that the varieties are correctly named. Furthermore, if one connected with a college or station desires to study varieties he must have an orchard under his supervision, and close at hand, so that he can assure himself beyond a doubt that errors of nomenclature do not exist." Wisconsin and Indiana report that the state horticultural societies in those states have taken over this matter, and West Virginia has made definite arrangements with orchardists for this work.

It is well worth including in the report several quotations from the letters in order to give the fullest idea of the members in regard to the general policy.

"I find that to know varieties thoroughly is the best possible introduction one could have to fruit men generally, whether amateurs or experts. Not to know varieties is to fall down. I find also that students are always interested in varieties, and that a good collection of varieties is a very great help in teaching. Besides all this, I strongly approve of variety testing because I believe that outside of the human element, the most important single factor making for success in commercial fruit growing is that of VARIETY. In my opinion a pomologist has got to know varieties, and to be able to discuss intelligently the value of each one and its range of adaptation throughout his province or state."

"Personally, I think much has been wasted with variety orchards. On the other hand, collections of varieties that show the different species and the important varieties for different sections are, of course, essential for satisfactory work in systematic pomology."

"I am of the opinion that climatic and soil conditions vary so much in the western states that it will be almost necessary for each state to

have a varietal test plat. We find in Nebraska, for instance, that our rainfall varies 50 to 75 per cent, and the altitude ranges from 1200 to 1300 feet in the eastern section to approximately 5000 feet in the western part of the state. Our soil conditions also vary from loess loam in the eastern section to extremely sandy soils in the central and western sections. We even feel that we should have test plats in the different parts of our own state."

"Personally, I can hardly say that I believe it worth while to attempt to maintain large variety test plots from a standpoint of the college. In the first place, in any one community there is not a large number of varieties that will grow to perfection. For class work it would seem almost better to depend on gathering in collections from various localities where particular varieties are grown in a commercial way."

"The trying out of new varieties must naturally be a part of the station work but the maintenance of an orchard where the attempt is made to grow a very large number of varieties that are already well understood or else have little commercial value, involves an expense altogether out of proportion to the benefits derived, at least it would seem so to me."

"In the case of a station which is surrounded by many extensive orchards with a fair collection of varieties, the variety test orchard would probably be of minor importance, but even in this case I believe such an orchard would be of very considerable value. In the case of stations which have available land suited to orcharding and where the station, as in our case, has few available orchards conveniently located for such studies, I believe that a rather large collection may profitably be maintained."

6. How many trees of a kind do you plant in testing varieties?

More report that they use two than any other number, however, there were 12 different combinations of numbers reported, but 32 out of 37 report numbers ranging from 1 to 5. Several indicated that it depended on the kinds of fruit in question, and others that they used 2 for first indications and for promising sorts they at once extended the number to 10 or more.

7. Do you use any special means of bringing the trees into early bearing?

The replies were a unit that they always preferred to use no such means, but several state that it was often convenient or necessary to do some top grafting in order to save space or get early fruiting. Others occasionally use dwarfing stock, or ring for the same purpose.

8. Do you have any seedlings or crosses of merit?

To this question 14 reported yes, 19 no, and 7 reported that the merits of their seedlings had not yet been determined.

9. Do you know of any extensive variety orchards owned by amateurs, nurserymen, commercial orchardists or others which should be listed by our Society for reference purposes?

The results of this question were somewhat disappointing for, although a rather long list of names are reported, yet it has not brought out as many distinctive orchards of the amateur class as had been expected.

However, 68 names were suggested which will be further examined and reported at a later date.

After working over the reports which have been received it seemed wise to separate them into groups depending upon the idea which seemed to be dominant in the mind of the writer. Some could readily be tabulated and appear in the general resumé of results while others seem to warrant quoting under certain questions, but mostly under question 5 which is the crux of the whole matter. Others, however, are of a general nature, bearing on the experience and judgment of those who have been working at this matter for a period of years and whose advice and counsel could well be presented apart from the detailed questions.

Professor S. A. Beach (Iowa) writes as follows:

"I have found in my experience as a horticulturist, that in carrying forward the pomology work under the circumstances as they existed at Geneva and also as they exist here at Ames, that it is a valuable asset to have at hand a living collection of the more important pomological varieties which can be grown at the station. Such a collection is of great assistance in keeping the constantly changing staff personnel somewhat acquainted with the behavior of the pomological varieties in the region where they are, for the time being, helping to serve. It seems to educate them and make them of much more efficient service to the experiment station, extension and college departments than they could otherwise be. Pomology has to do with the application of science to the art of fruit growing. The pomologist, therefore, needs to come in as close contact as possible with the problems which confront the fruit grower. It is granted that the testing of varieties is not the most important of these problems. Nevertheless, there is a continual demand on the part of the public for information regarding varieties and their behavior under various conditions and for their identification. A large percentage of the professional workers in pomology throughout the country are men under 30 years of age and a considerable number of them are less than 25 years of age. Very many of them have not had opportunity to get a personal acquaintance with the pomological varieties with which they are concerned and in which their constituency are interested. I regard, therefore, the question of maintaining a collection of pomological varieties at the station as of more importance than simply its bearing upon the proposition of carrying forward an experiment station project in variety testing."

As to the object or purpose of testing fruits at the various stations, we refer the reader to Bulletin 427, New York Experiment Station, by Dr. U. P. Hedrick.

The Ohio Experiment Station has been working on this matter of studying varieties for twenty-five years and I quote the comments of Professor W. J. Green (Ohio) in this connection:

"The last word has not been said on variety testing and may not be for some time. As a rule it is not worth while to spend much, if any, time to see which varieties do best in a given locality. The study of variety characteristics is worth while if well done. It is a basis for plant breeding. It makes a difference, however, how the work is done, no matter what the purpose. A beginner can do nothing of value, no one should

ever make a report on varieties until he has had several seasons' experience and some never can become adepts at the work because it requires a trained judgment to draw conclusions that are safe. In fact it is largely a matter of judgment. If a college or station has a man who has a passion for variety improvement and also has other requisite qualities he can use a variety orchard to good advantage, even though it is not in good fruit country. So, too, a man who loves to study varieties may make a variety orchard very useful. Variety studies are sometimes said to be less useful than formerly. This is true if a mere report upon behavior is meant. But such studies are more needed now by plant breeders; then, too, an instructor must know the varieties of fruit about which he instructs and he needs an orchard of varieties. He would be lame without such an orchard. A good orchard adds greatly to the prestige of the department and of the institution as a whole."

Dr. J. C. Whitten (Missouri) has made some interesting conclusions in regard to the matter and gives support to the contention that variety testing has yielded valuable material to the horticulturists. He writes as follows:

"When I came to this institution twenty-four years ago we began testing out quite largely a good many types and varieties of fruit. It seemed necessary then as fruit growing had a great impetus and large areas were being developed.

"Perhaps a more important purpose, however, was to get a knowledge of types and species and their weak or strong points in adaptability in this region. This information has served us in teaching, in investigating and in selecting types for crossing in our fruit breeding work.

"In recent years we have been reducing greatly this variety collection. We are trying to retain a few representatives of the leading species and types for systematic pomological study. We are also retaining varieties which have a purpose in our plant breeding.

"I am not much of a believer in variety testing just for the sake of observing simply what varieties yield best. I think that can better be found out by observing widely the commercial orchards in the state. Even the newer varieties are usually planted out in most of our soil formations on a commercial scale by somebody. I do believe, however, that a reasonable variety collection may be very important in studying the suitability of definite types of research problems and to teaching fundamental principles."

Professor C. I. Lewis (Oregon) gives his views as they relate to his western conditions and shows the extensive and intensive use to which variety testing can be put and the necessity of such work as a basis for certain fundamental pieces of research. Quoting his letter in part he says:

"As to whether or not an institution should have a large collection and should attempt to extend such a collection, it would depend, it seems to me, upon local conditions and objects in view. Our orchards are divided into two classes; namely, teaching orchards and experimental orchards. In the teaching orchards we would take, for example, perhaps a five to ten acre block of apples, three to five acres of which would be

planted to three or four commercial varieties which would be used for laboratory work, and the remaining acreage would be planted to about 300 varieties to be used in systematic pomology. Thus we enable the student not only to become familiar with the leading commercial apples produced in the United States, but will also enable him to become familiar with the habits of growth of the trees; and it is really essential to move such collections to teach pruning to the best advantage, so that the students may become thoroughly familiar with fruiting habits, and with the adaptation of the principles of pruning to various habits.

"In our experimental plots, we have a number of varieties for pruning investigations, pollination investigations, etc., but we are also doing a lot of work in horticultural products; that is, working out the canning values, evaporating values, fruit juice values, etc., of the various varieties. As this is a rapidly growing industry with us, such work is very necessary. We try also to introduce, from time to time, the new varieties and strains of fruits which the nurserymen are offering that we may be in a position to tell our fruit growers how these varieties compare with our present standard varieties." Extension work with the pear is also being carried forward in Oregon.

Professor J. E. Coit (California) discusses the problem from the standpoint of citrus and semi-tropical fruits as it exists in California, and I quote at some length from his letter:

"Taking up the question of varieties with the different fruits I will say that in regard to citrus fruits there is little need for any study of varieties because the history of the industry in California has been to eliminate rather than to add varieties. We are concentrating our entire energy on the Washington Navel and Valencia oranges, the Eureka and Lisbon lemons, and the Marsh pomelo. What we need is an improvement of our present varieties rather than new varieties. In connection with the new and rapidly expanding date industry of the Southwest, I will say that the question of variety collections is almost altogether in the hands of the United States Office of Seed and of Plant Introduction. The best collection exists in the co-operative date gardens at Tempe, Arizona, which is operated jointly by the Arizona Experiment Station and the Office of Seed and Plant Introduction. Small collections of varieties may also be found at the government date gardens at Mecca and Indio, California. Extensive collections and plantations of seedlings are now coming into fruiting throughout the arid Southwest.

"In connection with the avocado, I may say that the industry is just now in a vigorous boom, and is expanding with marked rapidity. The California Avocado Association has a committee on varieties which is working almost continuously and publishing lists and descriptions from time to time. Inasmuch as none of the branch experiment stations are located in what may be called suitable and satisfactory climatic regions for the avocado, it is unlikely that these stations will attempt, within a few years at any rate, to establish any large collection of varieties. Any seedling of any value is quickly located, and a careful study made on the ground by members of the Association committee.

"In regard to figs, the University 25 years ago planted several collections of varieties. These have all been abandoned. At the present

time Professor Condit of this division is making a rather exhaustive study of fig varieties. He is using mainly the two large collections—one of Mr. J. L. Nickel, of Menlo Park, California, consisting of more than 100 varieties, the other the government collection at the Seed and Plant Introduction Gardens at Chico, California, where there are some 80 varieties of figs in bearing.

"In regard to the olive, variety studies carried on many years ago eliminated a very large list of imported European varieties, and narrowed them down to 6 or 8, of which only 3 or 4 are grown commercially at the present time. Apparently there is no need for any systematic study of the varieties of olives. Perhaps Mr. George Roeding, of Fresno, has as large a collection of olive varieties as anyone in the state.

"In regard to the semi-tropical fruits of lesser importance, I may say that the following two men have the best collections that I know of: Mr. C. P. Taft, Orange, California, especially good for loquats, Japanese persimmons, guavas, avocados, feijoas, and carisas. Mr. F. O. Popenoe, West India Gardens, Altadena, California, especially good for dates, avocados, feijoas, passifloras, and the more tropical things such as mangoes, et cetera."

GENERAL CONCLUSIONS.

In general the institutions are pretty well supplied with variety material, the apple leading all other fruits in these plantings. Peaches, pears and grapes are receiving much consideration in some places. Extensive work in originating new varieties is going on in several places.

While conditions vary at institutions and probably always will, there is a general feeling that at least the more prominent varieties for the region should be grown at each station and college, and representatives of the various original stocks should be maintained for instructional purposes. Where there is a strong tendency to extend variety orchards it is usually with the idea of providing material for fundamental research or for one of several new fields which are developing. The inquiry also explains why in many places there is good reason for not maintaining extensive variety orchards and therefore justifies the assumption that at least within limits one institution can well make free use of another in this regard and then check up on the information in the orchards of growers throughout the state.

REPORT OF THE COMMITTEE ON SCORE CARDS FOR VEGETABLES.

By W. W. TRACY, SR., CHAIRMAN, *Department of Agriculture,*
Washington, D. C.

It would seem as though the more complete and distinct as to varietal characters a scale of points is, the more helpful it will be, but in practice it is found that generally and especially when each exhibit is made up of a number of specimens, the judges' decision is based on general impres-

sions rather than on a study of individual characteristics. Your committee has therefore thought it wise to recommend that in the case of single varieties, a uniform maximum allowing of 35 points of a possible 100 be given to varietal character and labeling, and the remaining 65 points to display and quality of the exhibit; and in the case of collections, 30 points be allowed to varietal character and labeling, and 70 points for display and quality, and suggest that the Society recommend that these official allowances be printed on all labels of exhibits, as follows:

Single Variety: Possible 35 points allowed for Varietal Character Character and Correct Labeling; 70 points for Display and Quality.

Collection of Varieties: Possible 30 points allowed for Varietal Character and Correct Labeling; 70 points for Display and Quality.

As a guide to judges and in the hope of securing greater uniformity in awards we submit a table of relative values of different characters for each vegetable, with the suggestion that it be adopted as official and that it be as generally distributed as practicable.

A few sample score cards for vegetables are given herewith and copies of the complete list will be sent to the members for criticism and revision:

BEET.

<i>Single Variety.</i>		<i>Collection of Varieties.</i>	
Condition of exhibit	15	Number of varieties shown	20
Correct varietal character	25	Condition of exhibit	20
Labeling	10	Correct varietal forms	20
Uniformity of sample	10	Labeling	10
Outer color	10	Outer color	10
Flesh color and tenderness	10	Smoothness of surface	10
Freedom from side roots	10	Freedom from side roots	10
Smoothness of surface	10		

CABBAGE.

<i>Single Variety.</i>		<i>Collection of Varieties.</i>	
Condition of exhibit	15	Number of varieties shown	20
Correct varietal character	25	Condition of exhibit	20
Labeling	10	Correct varietal form	20
Size of head	20	Labeling	10
Solidity	10	Size of heads	10
Crispness	10	Solidity	10
Color	10	Color	10

POTATO.

<i>Single Variety.</i>		<i>Collection of Varieties.</i>	
Conditions of exhibit	15	Number of varieties shown	15
Correct varietal character	25	Condition of exhibit	15
Labeling	10	Correct varietal forms	20
Size	10	Labeling	10
Freedom from blemish	10	Size	10
Character of skin	10	Freedom from blemish	10
Form and color of eyes	10	Character of skin	10
Character of flesh	10	Character of flesh	10

TOMATO.

<i>Single Variety.</i>		<i>Collection of Varieties.</i>	
Condition and display.....	15	Number of varieties shown....	20
Correct varietal character.....	25	Condition and display	20
Labeling	10	Correct varietal forms	20
Freedom from blemish	10	Labeling	10
Flesh solidity	10	Varietal uniformity of sample.	10
Flesh color	10	Color	10
Flesh flavor	10	Solidity	10
Even ripening	10		

THE EFFECT OF SOIL CONDITIONS ON THE NITROGEN CONTENT OF THE HEAD LETTUCE PLANT.*

BY H. A. NOYES AND C. B. SAYRE, *Purdue University, Lafayette Ind.*

Intensive horticultural greenhouse crops are grown by specialists. There are things in their growing that are not apparent to the average agriculturist. The procedure usually followed by successful greenhouse men in handling soil is to select a soil, compost it with manure for some time and place it in the greenhouse. In the greenhouse it is manured and fertilized heavily for each crop grown upon it. The result of experience are that soils heavily fertilized in this way can not be depended upon to produce successful crops after the first two years (because of results of over-fertilization) and the soil is removed and a new start made.

Head lettuce is admitted to be one of the hardest crops to grow in the greenhouse. In addition to proper heat, light and ventilation the physical condition of the soil and the fertilization practiced are recognized as important. The results reported upon here were obtained in a preliminary experiment where an attempt was made to get outside those physical and chemical factors of the soil which determine the successful production of head lettuce in the greenhouse.

SOILS USED AND TREATMENT GIVEN.

The soils used were:

1. Bank sand containing very little available plant food.
2. A mixture of bank sand and manure containing three bushels of sand to two bushels of manure.
3. A brown silt loam soil of more than average fertility.

The fertilizing materials used were: Partially rotted manure, 16 per cent acid phosphate, nitrate of soda and muriate of potash.

The plots include the following different fertilizations:

*This paper was read at the 1916 meeting, but the manuscript was not furnished for the 1916 report..

TABLE I.

—	Nothing.
P.	400 pounds of acid phosphate.
N ₃ , P	133 pounds nitrate of soda, 400 pounds acid phosphate.
N, P ₃	400 pounds nitrate of soda, 133 pounds of acid phosphate.
N ₃ , P.K.	133 pounds of nitrate of soda, 400 pounds acid phosphate, 200 pounds of muriate of potash.
N. K.	400 pounds nitrate of soda, 200 pounds of muriate of potash.
N.	400 pounds of nitrate of soda.
M. N ₃ P.	20 tons manure, 133 pounds nitrate of soda, 400 pounds acid phosphate.
M.	20 tons of manure.

The treatments given in Table I were run on the silt loam (in Series A and B), further a series receiving one half these fertilizers treatments (C) was also run on the silt loam.

Two series of plots were conducted on the bank sand, one receiving the regular treatments given in Table I (D) while the other received these treatments doubled (H) (no manure plots were in H).

On the sand and manure mixture three sets of plots corresponding to those on the soil were run. Series E and F were duplicates with the fertilizer treatments given in Table I, while G received one half the treatments given in the table. (No manure plots were run on the sand and manure mixtures.)

VARIETY OF LETTUCE USED AND CROP RESULTS.

The variety of head lettuce grown was "May King." The plants were grown in flats and transferred to the greenhouse plots when about three inches in diameter.

The greenhouse was run under the temperatures considered favorable for head lettuce, and the crop harvested ten weeks after setting in the greenhouse when it appeared that the plants had headed as much as they would under the conditions of soil treatment given. The average weights of the plants grown on the different series are given in Table II.

TABLE II.

Series A & B without manure plots, 121 grams. Manure plots averaged 155 grams.
Series C without manure plots, 87 grams. Manure plot averaged 111 grams.
Series D without manure plots, 63 grams. Manure plot averaged 86 grams.
Series H, 66 grams.
Series E and F. 73 grams.
Series G. 55 grams.

The full data from which Table II was drawn shows that the weight of lettuce produced due to the addition of chemical fertilizers was small. On the sand and also on the soil series the manured plots showed good increases, but there was evidently more manure in the sand and manure mixture than was either beneficial to growth or amendable by the fertilizer salts added.

NITROGEN CONTENT OF PLANT.

It was desired to ascertain just how the fertilization had affected the composition of the plants grown. The soils used varied so in organic matter and nitrogen content that the nitrogen content of the plants grown on the different soils and under the different treatments was determined. The result of these determinations based on the air-dry plants appear in Table III.

TABLE III.

PER CENT NITROGEN IN AIR-DRY HEAD LETTUCE PLANTS.

	Silt Loam Per cent	Bank Sand Per cent	Sand and Manure Mixture Per cent
Check	3.73	2.40	3.68
200 lbs. Acid Phosphate.....	3.34	.....	.....
400 lbs. Acid Phosphate	3.50	1.72	3.59
800 lbs. Acid Phosphate.....	.....	1.51	.....
67 lbs. NaNO_3 , 200 lbs. Acid Phosphate.....	2.73	.....	.....
133 lbs. NaNO_3 , 400 lbs. Acid Phosphate.....	3.77	2.17	3.65
267 lbs. NaNO_3 , 800 lbs. Acid Phosphate.....	.....	1.93	.....
200 lbs. NaNO_3 , 67 lbs. Acid Phosphate.....	3.90	.....	.....
400 lbs. NaNO_3 , 133 lbs. Acid Phosphate.....	4.12	1.65	3.66
800 lbs. NaNO_3 , 267 lbs. Acid Phosphate.....	.....	2.32	.....
67 lbs. NaNO_3 , 200 lbs. Acid Phos. 100 lbs. KCl ...	2.90	.....	.....
133 lbs. NaNO_3 , 400 lbs. Acid Phos. 200 lbs. KCl ...	3.78	2.25	3.58
267 lbs. NaNO_3 , 800 lbs. Acid Phos. 400 lbs. KCl}...	.....	2.48	.....
200 lbs. NaNO_3 , 100 lbs. KCl	3.60	.....	.....
400 lbs. NaNO_3 , 200 lbs. KCl	3.83	2.17	3.61
800 lbs. NaNO_3 , 400 lbs. KCl}.....	.....	2.45	.....
200 lbs. NaNO_3 , ...	3.16	.....	.....
400 lbs. NaNO_3 , ...	3.46	2.60	3.27
800 lbs. NaNO_3, .....	.....	2.73	.....
10 Tons Manure, 67 lbs. NaNO_3 , 200 Acid Phos....	3.65	.....	.....
20 Tons Manure, 133 lbs. NaNO_3 , 400 Acid Phos...	3.75	2.09	.....
10 Tons Manure.....	3.37	.....	.....
20 Tons Manure	3.85	2.39	.....
Average	3.56	2.19	3.58
Variation	1.39	1.22	0.41
Average for same fertilization.....	3.75	2.16	3.58
NaNO_3 = sodium nitrate.			
KCl = muriate of potash.			

Some of the points brought out in the table are:

1. In the soil series phosphorus decreased the nitrogen content of the plant. The addition of a little nitrogen to the phosphorus raised the percent of nitrogen, but not up to that in the check plants. More nitro-

gen and less phosphorus raised the nitrogen content to 0.25 percent above the check. The above indicates that nitrogen promoted leafy growth while phosphorus tended to hasten maturity.

2. The manure plots in the soil and the bank sand series gave plants analyzing about the same in nitrogen as the check plots. This indicates that both the silt loam and the bank sand were well balanced in the amount of plant food they contained.

3. Halving the fertilizer treatments on the silt loam and doubling them on the bank sand confirmed the phosphorus effects connected with I & II.

4. The sand and manure mixture series were much more constant in their nitrogen content due to excessive amounts of manure applied.

5. The variation between the average nitrogen content of the plants grown on the silt loam with regular fertilization and those grown on the bank sand was 1.59 per cent nitrogen.

6. The highest nitrogen content, 4.12 per cent was found in plants grown on the silt loam with 400 pounds sodium nitrate and 133 pounds acid phosphate per acre.

7. The lowest nitrogen content, 1.51 per cent was found in plants grown in bank sand with 800 pounds acid phosphate per acre.

This maximum variation in nitrogen content obtained was 2.61 per cent based on the air-dry plants. This is equivalent to 16.31 per cent protein using the usual feed factor 6.25. Figuring back to the wet basis the maximum variation in the protein content of the lettuce plants as harvested was 1.63 per cent protein (which is more than one-half the protein content of milk).

SUMMARY.

The nitrogen content of the head lettuce plant can be modified by the fertility of the soil and the relative fertility of the three soils used determined the effects of fertilization on the nitrogen content of the plants grown.

The usual phosphorus and nitrogen effects were confirmed, phosphorus hastening maturity and nitrogen promoting leafy growth.

Fertilization affected the composition of the plants more than was expected which is confirmatory of the statement made at the outset, namely, intensive greenhouse crops are successfully grown under exact physical and chemical conditions, which need to be intensively investigated.

LINES OF WORK CONDUCTED BY OUR MEMBERS.

(Note: This list is incomplete because some of the members did not reply to the Secretary's letter asking for the desired information. A letter was sent to every State in the Union.)

DOMINION OF CANADA.

CENTRAL EXPERIMENTAL FARM, *Ottawa.*

Same list as last year.

EXPERIMENT STATION, *Kentville, N. S.*

Variety tests of apples, pears, stone fruits and small fruits. Orchard fertilization.

Close vs. wide planting of trees.

Home-grown vs. imported trees.

Spraying experiments in orchards.

AGRICULTURAL COLLEGE, *Guelph.*

Pollination studies.

Inheritance of size and vigor in horticultural plants.

Demonstration of summer pruning of Northern Spy; top-grafting Ben Davis to better varieties; root pruning to hasten fruiting.

ONTARIO HORTICULTURAL EXPERIMENT STATION, *Vineland Station.*

Variety tests of 164 varieties apples, 81 pears, 6 quinces, 190 peaches, 10 apricots, 3 nectarines, 159 plums, 93 cherries, 163 grapes, 33 currants, 31 gooseberries, 83 strawberries, 3 raspberries, and blackberries and dewberries.

Fall vs. spring plowing of various orchard cover crops.

Six systems of orchard cultivation.

Winter vs. summer vs. non-pruning of apples.

The effect of crown gall on apple trees.

Dwarf vs. standard pear trees.

Spring and fall planting in dynamited and dug holes of pears and plums.

Degree of self-fertility of commercial pear varieties.

Extended test of leading commercial varieties of grapes.

Comparative test of various grape pruning systems.

Correlation between number of buds left and vigor, productiveness and longevity of grape vines.

Self-fertility tests of leading varieties of grapes.

Value of certain self-fertile varieties as pollenizers for self-sterile varieties of grapes.

Grape seed germination experiments.

Determination of sugar and acid content of commercial varieties of grapes at various stages of maturity.

Irrigation of strawberries and raspberries.

Improvement of strawberries by runner selection.

Test of various varieties of strawberries for jam making.

Variety test of 11 varieties asparagus.

Irrigation and fertilizer experiments with asparagus, onions, carrots, celery, early beets.
 Northern vs. southern grown potatoes as seed tubers.
 Hill selections of potatoes.
 Improvement by seed selection of beets, carrots, celery, melons, onions, peas, rhubarb, tomatoes.
 Commercial vegetable seed production.
 Soil temperature determinations under irrigation.
 Plant breeding of apples, pears, plums, peaches, cherries, strawberries, raspberries, blackberries, dewberries, currants, gooseberries, tomatoes, cucumbers and various native species of fruits desirable.

MACDONALD COLLEGE, *Macdonald College, P. O.*

Pollination of McIntosh and Fameuse apples, cover crops and fertilizer experiments with apples.
 Variety testing of fruits.
 Variety and strain test of onions and cabbages.
 Seed growing and selection of bean, beet, carrot, sweet corn, tomato and peas.

UNITED STATES DEPARTMENT OF AGRICULTURE.

Same list as last year.

ARIZONA.

UNIVERSITY OF ARIZONA, *Tucson.*

Hatch Fund.
 Varsity testing of dates.
 Storage of sweet potatoes.

CALIFORNIA.

UNIVERSITY OF CALIFORNIA, *Berkeley.*

AND

EXPERIMENT STATION, *Davis.*

Pollination of *domestica* and *triflora* plums under California conditions.
 Student laboratory plantings—a study of fruit tree stocks, pruning and planting methods.
 Almond culture.
 Planting distances for deciduous orchard trees.
 Apricot pruning.
 Pecan culture.
 Irrigation of orchards and small fruits.
 Orchard soils investigations—effect of tillage practices on soil moisture content and growth of trees.
 Orchard soils investigations—tests of mulches for orchard trees.

- Pollination studies with almonds, cherries and pears.
- Fruit bud formation in deciduous fruits.
- Pruning studies with deciduous fruits.
- Variety tests of fruits for drying.
- Inter-cropping of orchards.
- Nature and causes of growth periodicity in fruit trees.
- Relation of growth stimuli to fruitfulness and quality of product in orchard trees.
- Orchard management.
- Survey of fruit drying industry of the state.
- Effects of sulphuring on fruit tissue and its possible relation to palatability of the product.
- Cold storage of grapes.
- Standardization of fruit drying methods.
- Equipment for fruit drying.
- Effects of stacking (the trays) in drying fruits.
- Cold storage of pears.
- Keeping qualities of apples in cold storage as affected by the health and vigor of the trees.
- Effects of stage of ripeness on the keeping quality of apples in cold storage.
- Vegetable growing on the University Farm.
- Potato breeding. Hill selection of tubers; field selection regardless of the hills from which they come.
- Commercial production of vegetable seed.
- Capri figs and caprification.
- The production of dried figs.
- The fresh fig industry, including a systematic study of fig varieties.
- The Japanese persimmon in California.
- Date culture in California.
- The June drop of the Navel orange.
- The seedlessness of the Navel orange.
- The avocado industry in California and the commercial varieties being grown.
- Improvement of bearing of vine varieties by selection.
- Tests of new or little known varieties of vines.
- Resistant stocks for California vines.
- Effects of early and late pruning of vines.
- Disinfection of roots and cuttings with hot water.
- Relation of degree of maturity of grapes to quantity and quality of raisins.
- Resistant stocks for raisin varieties.
- Wine grapes for the San Joaquin Valley.
- Varieties and methods suitable for grape growing in Imperial Valley.
- Coating for cement wine vats.
- Amounts of wine and by-products yielded by grapes in California.
- Improvement of methods of preparing unfermented grape juice.
- Standards of composition of California grapes and wine.
- Improvements of the methods of vinegar making in California.
- Methods of germinating olive seeds.

- Preparation of collection of olive trees at Davis, Kearney and Imperial and of specimens at Berkeley.
- Improvement of methods of pickling olives.
- Demonstration of improved methods of Enology—in co-operation with the Extension Division.
- Effect of the use of various fertilizers on a vineyard growing in a good well-balanced soil. (In co-operation with the Divisions of Soils and Fertilizers.)
- The effects of frost on vines and methods of control.
- Studies in jelly making.
- Use of tannin in white wine making.
- Studies of methods of chemical analysis of wine.
- Effect of low temperature of sterilization on quality of canned fruits.
- Collection of data to aid in the establishment of standards for wine, raisin and shipping grapes.
- Cost of the manufacture of olive oil and pickles in California.
- Unfermented orange juice.
- A study of methods of making glacé fruits.
- Unfermented lemon juice.
- Ratio of Balling-Alcohol-Sugar in a fermenting grape must.
- Methods of preparing fruit juices.
- Utility of winter spraying in the control of vine mildew.
- Comparison of the effects of long and short pruning on varieties which are commonly pruned both ways.
- Reduction of the amount of fortification of sweet wines.
- Relative fruitfulness of canes originating on two-year-old wood (fruit-canes) and canes originating on older wood (water-sprouts and suckers).
- Effects of summer pruning on the quantity and quality of the crop and on the vigor of the vine.
- Best arrangement and pruning of vines in a Muscat vineyard.
- Raisins as a feed for swine.
- Extraction of olive oil by centrifugal force.
- Relation of the number of vines per acre to the quantity and quality of the crop.
- Irrigation of vineyards. (Continuation of informal co-operation running since 1911.)
- Abnormal tastes and odors in olive oil.
- Relation of *Oidium* to the keeping qualities of shipping grapes.
- Demonstration of method of growing raisin grapes.
- Table grapes for the San Joaquin Valley.
- A study of the thermal death point of *Bacillus botulinus*, especially in relation to the sterilization of canned vegetables.
- Grape syrup as a substitute for sugar in canning.
- Canning and preserving fruit without sugar.
- Economical drying of wine and table grapes.
- Drying vegetables.
- Home drying of fruit.
- Preservation of vegetables with salt.

The functions of sulfurous acid in the drying of fruit and in the storage of dried fruit.

The sugaring of dried fruits.

New methods of packing dried fruits.

A study of the maximum water content of dried fruits.

A study of methods of fruit drying designed to prevent darkening of fruit during process without use of sulfurous acid.

The best stage of ripeness at which to harvest fruit for canning, drying, and the preparation of jams, jellies and other fruit products.

A study of the dipping of fruits preliminary to drying.

STATE COMMISSION OF HORTICULTURE, *Sacramento*.

State fund.

Control of mealybugs on citrus trees, the sugar beet leaf-hopper, and the black scale.

Control of aphid by the use of the common ladybird beetle, *Hippodamia convergens*.

CITRUS EXPERIMENT STATION, *Riverside*.

Fertilizer requirements of citrus trees.

A study of the varieties of citrus fruits and their relatives.

Crown gall.

Gum diseases.

Routine examination of material sent to the Citrus Experiment Station, and minor studies in mycology and bacteriology.

Root diseases of citrus trees.

Fruit spots and stains.

The breeding and improvement of citrus fruits.

The principles of heredity in certain plants.

The origin, nature, and inheritance of apparent mutations in certain plants.

Citrus survey.

Observations and studies on internal decline of lemons.

A study of the fumigation process with special reference to the chemical problems involved.

A study of the chemical and physical effects of nitrate of soda on citrus soils.

Spraying for insect pests on citrus and olive trees.

Study of cost accounting for citrus orchards with a view to determining as far as possible the actual value of cultural practices.

Experiment in the management of old groves.

Walnut breeding investigation.

Walnut rootstock investigation.

A physiological study of the effect of pruning upon the growth and productiveness of citrus trees and other horticultural plants grown under irrigation in arid regions in Southern California.

Walnut blight—investigation for control.

Sunburning and winter-killing of walnut trees.

Covercrop breeding.

Field trials with fertilizers and green manure crops with walnuts.

CONNECTICUT.

AGRICULTURAL COLLEGE, *Storrs.*

Variety testing of apples, pears, peaches, plums, cherries, small fruits and vegetables.

EXPERIMENT STATION, *New Haven.*

Same as last year.

DELAWARE.

EXPERIMENT STATION, *Newark.*

Adams fund.

Role of potash, phosphoric acid and nitrogen in growing peaches.

Hatch fund.

Role of potash, phosphoric acid, nitrogen in growing apples.

Heredity studies of peaches.

Heredity studies of cabbage.

Cytology of peach fecundation.

Cytology of cabbage fecundation.

Hatch and other funds.

Variety tests of apples, pears, peaches, plums and grapes.

Comparative tests of varieties of pole lima beans.

Comparative tests of varieties of bush lima beans.

Comparative tests of cover crop in peach orchards.

Comparative tests of cover crop in apple orchards.

Central leader versus open head in apple trees.

Smith-Lever and Other Funds.

Dust sprays for apples and peaches.

Top dressing peach orchards with nitrate of soda.

Pruning of peach and apple trees.

Dusting strawberries for weevils.

Thinning apples and peaches.

Spraying tomatoes for septoria leaf spot.

GEORGIA.

UNIVERSITY OF GEORGIA, *Athens.*

State Fund.

Fertilization of apples.

Study of pecan rosette.

Tomato breeding for disease resistance.

Fertilization of tomatoes.

Smith-Lever Fund.

Home gardens.

Home orchards.

ILLINOIS.

UNIVERSITY OF ILLINOIS, *Urbana*.

State Fund.

Selection for certain characters in roses and carnations.

Carnation breeding.

A study of physiological diseases of greenhouse plants.

Lettuce breeding studies.

Soil mixtures for greenhouse lettuce and tomatoes.

Tomato selection for *Fusarium* resistance.

Fertilizer experiments with tomatoes, melons, and sweet potatoes.

Sweet potato selection tests.

Dried bean production.

Rots of onions in storage.

Adams Fund.

Bud selection of apples.

Growing seedlings from selected fruits.

Sweet pea breeding.

Strawberry breeding (in abeyance).

Hybrid apple breeding.

Peach breeding.

Experiment Station Fund.

Soil management for apples.

Soil management for peaches.

Soil fertility problems for apples.

Soil fertility problems for peaches.

Investigations on the control of fire blight.

Investigations in cool and cold storage of fruits.

Methods of dehydrating fruits.

Varieties tests of apples, pears, peaches, plums, cherries, apricots, grapes, raspberries, blackberries, gooseberries, currants, and strawberries.

Field experiments on various cultural methods, including spraying, for small fruits.

Hatch Fund.

Investigations of various fruit rots.

Investigations on the control of diseases affecting the wood of apple trees.

Peach pruning experiments.

State and Adams Funds.

Field experiments on the control of apple insects and fungous pests.

IOWA.

IOWA STATE COLLEGE, *Ames*.

Adams Fund.

Apple breeding, in study of unit characters and development of desirable varieties for the Upper Mississippi Valley.

Orchard humus investigations, effect of varying amounts of humus on tree growth and fruitfulness.

State and Other Funds.

- Spraying of apple orchards.
- General fruit breeding.
- Orchard stocks investigations.
- Variety studies
- Vineyard investigations.
- Orchard heating.
- Cold and common storage of Iowa apples.
- Study of Jonathan spot on apples in storage.
- Crown gall of nursery stock.
- Orchard management, including apple pruning, fruit thinning, crop re-
porting, and cherry investigations.
- Control of blister canker of the apple.
- Orchard fertilizer investigations.

KENTUCKY.

UNIVERSITY OF KENTUCKY, *Lexington.*

State Fund.

- Study of pollination, self-sterility, etc., of tree fruits.
- Insecticides for scale control.
- Comparison of spray materials.
- Adaptation of vinifera grapes.
- Spraying of grapes.
- Variety tests and methods of planting of small fruits.
- Pruning, training and spraying tomatoes.

Smith-Lever Fund.

- Orchard pruning and spraying.
- Organizing co-operative organization for crop production and marketing.
- Orchard management.
- Grading, packing and marketing cantaloupes and other truck crops.

State Fund (Demonstration).

- One co-operative orchard for orchard management, use of fertilizers, etc.

MARYLAND.

MARYLAND STATE COLLEGE, *College Park.*

Same as last year.

MASSACHUSETTS.

AGRICULTURAL COLLEGE, *Amherst.*

Adams Fund.

- Studies in plant breeding—inheritance of pigmentation in garden beans;
isolation of pure races in squashes; correlation of seed weight and
vine length in peas; effect of selection within the pure line in peas.
- The interrelation of root and scion in apples.
- Breeding peaches.
- A study of tree characters in fruit varieties.

A study of the relation of light to greenhouse, garden and field crops.

Why insecticides burn foliage.

To determine the characteristics, life, histories, habits, and control of all cranberry insects.

State and Other Funds.

The climatology of fruits—effect of local climate on varieties; relation of topography to winter killing of fruit buds in peaches.

Pruning experiments with apples with especial reference to head formation.

The effect of cover crops on growth and production in apples.

Tests of varieties of fruits.

Experiments in the intensive planting of fruits.

Tests of spray materials and methods.

The behavior of apples in cold storage.

Fertilizer tests in the apple orchard.

Fertilizer plot tests with small fruits and vegetables.

The production of rust resistant varieties of asparagus.

Cranberry investigations, diseases, frost observation and protection, bog management.

Blueberry culture.

Investigation of a stem disease of greenhouse roses.

Experimental spraying of beans for control of anthracnose.

Experimental spraying of celery for control of late blight.

Study of the value of arsenate of lime as a substitute for arsenate of lead as a spray material.

Dates of hatching of oyster shell scale, scurfy scale and white pine scale.

The control of the onion maggot.

Study of the number of broods of the codling moth.

Study of cyclamen mite.

The poisoning of bees resulting from spraying fruit and shade trees with arsenical poisons.

Smith-Lever Fund.

Demonstration in fifteen orchards which have been set since 1910.

Demonstration of the manufacture of orchard by-products.

Lectures and demonstrations at extension schools.

A pruning, spraying and apple grading and packing campaign.

A state-wide campaign for the observation of a national apple day.

Monthly letters to county agricultural agents.

Occasional letters to demonstration orchard owners.

MARKET GARDENING STATION, *Arlington.*

Test of asparagus.

Test of commercial varieties and new or improved varieties of standard vegetables.

Stable manure vs. various combinations of green manures and commercial fertilizers with definite rotations of vegetable crops.

Insect control of cabbage, spinach, squash, etc.

Disease control work on celery, cucumbers and tomatoes.

MICHIGAN.

AGRICULTURAL COLLEGE, *East Lansing.*

Same as last year

MINNESOTA.

UNIVERSITY OF MINNESOTA, *St. Paul.*

Adams Fund.

Study of inheritance of fruit characters.

Breeding for hardiness in fruits.

State Funds.

Studies of sterility in fruits.

Pruning the apple.

Co-operative orchard management experiments.

Cider and vinegar making qualities of Minnesota apples.

Blueberry studies.

Nut culture.

Study of relation between structure and hardiness in the plum.

Variety tests of fruits.

Breeding and selection of bean, cucumber, lettuce, melon, onion, pea, squash, and tomato.

Potato investigations in hill selection, the testing of varieties and seed-linings, and in maintaining yield.

Studies of ornamental varieties and uses of annuals, perennials, shrubs, hedges and dahlias.

MISSOURI.

UNIVERSITY OF MISSOURI, *Columbia.*

Adams Fund.

A study of the factors influencing the rest of horticultural plants.

Orchard and strawberry nutrition.

State Fund.

Spraying fruits for insect and fungous diseases.

Hatch Fund.

Asparagus selection.

Investigations with seed potatoes.

Fruit bud development of fruit trees as influenced by treatment and previous crops.

Handling and hardening off vegetable plants.

Bud selection for increasing yields of apples.

The nutrition of fruits with special reference to their hardiness.

Self fertility and self sterility of fruits.

Fall vs. spring planting of trees.

Orchard heating (in years when late spring frosts occur).

Treatment of apple canker diseases.

Apple breeding for late blooming habit.

Orchard tillage—sod, clean cultivation, mulch, combined cultivation and cover crops.

Peach breeding for hardy sorts.

Examination of buds in winter for forecasting probable bloom.

Smith-Lever Fund.

Pruning and spraying grapes.

Renovating old orchards by pruning and spraying.

Shaping young orchards.

Grading and packing fruit.

MONTANA.

UNIVERSITY OF MONTANA, *Bozeman*.

Same as last year.

NEBRASKA.

UNIVERSITY OF NEBRASKA, *Lincoln*.

Adams Fund.

Winter injury investigations.

Hatch and State Funds.

Principles of orchard culture.

Plant breeding.

Potato selection for seed purposes.

Tuber line selection of potatoes for increased yield.

Fruit breeding.

Spraying apples, pears, grapes and bush fruits.

Pruning apples, pears, and small fruits.

Treatment of Illinois blister canker of apple trees.

Smith-Lever Fund.

Pruning and spraying of fruit trees.

NORTH CAROLINA.

STATE DEPARTMENT OF AGRICULTURE, *Raleigh*.

State Fund.

Practicability of commercial pecan culture.

Pecan breeding.

Commercial production of summer apples in Eastern North Carolina.

Muscadine grape work—culture, pruning and trellising, fertilizing, variety testing, producing new varieties.

Fruit variety adaptation.

Peach breeding.

History and descriptions of fruits native to North Carolina.

An investigation of thermal belts or frostless zones.

Sweet potatoes—planting, storing, and disease control.

Cabbage—varieties for storage and methods of storage.

Irish potatoes—varieties for mountain conditions, producing seed for early crop in coastal region, hill and tuber unit selection, keeping and cooking qualities.

Adams Fund.

Self-sterility in blackberries and dewberries.

Study of transmission of characters in hybrids of *Rotundifolia* grapes.

Smith-Lever Fund.

Orchard demonstration work—locating orchards; budding, grafting and top-working; planting, pruning, spraying and packing; classifying and judging fruits at fairs.

EXPERIMENT STATION, *West Raleigh.*

Study of transmission of characters in hybrids of *Rotundifolia* grapes.

Studies of inheritance of sex, size and color of *Rotundifolia* grapes.

Productivity of *Rotundifolia* grapes.

Study of quality characters in *Rotundifolia* grapes.

Hybridization of *Rotundifolia* grapes with other varieties.

NEW HAMPSHIRE.

EXPERIMENT STATION, *Durham.*

Adams Fund.

Fruit bud formation.

Inheritance of color in carnations.

Mendelian inheritance in squashes.

Hatch Fund.

Variety test of apples, plums and small fruits.

Study of the status of the blueberry industry in New Hampshire.

Study of sod mulch system for orchards.

Study of cultivation for orchards.

Test of various cover crops for orchards.

Miscellaneous.

Adaptation of varieties of tomatoes to New Hampshire conditions.

Variety test of tomatoes for forcing in the greenhouse.

A study of vegetable pits and trenches.

A study of temperatures maintained in vegetables pits and trenches in a northern climate.

NEW YORK.

CORNELL UNIVERSITY, *Ithaca.*

State Funds.

Research Projects:

Osmotic relationship and incipient drying in fruit trees.

Hardiness studies.

Bush fruits fertilizer experiments.

Pruning experiments with young trees.

Pruning experiments with old trees.

Color in fruits.

A study of the causes of the June drop with fruit trees.

A study of the behavior of the individual fruit spurs as a result of thinning.

Extension Projects:

The extension work is conducted by means of demonstration schools, winter short courses, personal farm visits, lectures, demonstrations, correspondence courses, personal correspondence, educational exhibits at fruit growers' meetings, state and county fairs, and production and marketing small fruits and tree fruits. A large proportion of the work is handled in co-operation with county farm bureau agents.

EXPERIMENT STATION, Geneva.

Fruit variety testings and descriptions.

Fruit breeding, particular attention being given to apples, pears, grapes, raspberries and strawberries.

Vinifera grapes—variety testing and breeding.

Apple orchard fertilization.

Orchard tillage experiments and cost of growing apples.

Pruning—heavy vs. light, and high vs. low heading with apple, pear, plum, peach and cherry; summer vs. winter pruning with the peach and apple; tests of various dressings for wounds.

Bud selection in apples and violets.

Vineyard fertilization (vineyard sub-stations).

Pruning and training varieties of grapes (vineyard sub-stations).

Desirable stocks for grapes (vineyard sub-stations).

Study of temperature and water requirements of varieties of grapes (vineyard sub-stations).

Tomato, cucumber and melon breeding.

Cabbage—the relative value of selfed and open pollinated seed.

Beans—selection for disease resistance.

Garden peas—a study of pure lines.

Culture of little known vegetables.

Rose and orchard breeding to study color inheritance.

OHIO.**EXPERIMENT STATION, Wooster.**

Same as last year.

OHIO STATE UNIVERSITY, Columbus.

Demonstrations—all-year demonstrations in pruning, spraying, fertilizing, thinning, grading and packing in 40 orchards. Also 150 other pruning and spraying demonstrations.

Illustrated lectures and practical work in landscape gardening for homes and rural schools.

OREGON.

AGRICULTURAL COLLEGE, *Cornwallis*.

Adams Fund.

Cause of sterility in pomaceous fruits.

Investigations of critical temperature in connection with frost damage.

Influence of moisture in development of pear trees as relates to vigor, bud, foliage and fruit.

Relations of pruning methods to wood growth, bud formation and fruit development.

State and Other Funds.

Relations of depth of planting to vigor of fruit trees.

The value of various stocks for prunes.

Loganberry pruning.

Plant breeding with apples, cherries, prunes, and strawberries.

Variety tests at home stations and sub-stations with over 2000 varieties of nuts and fruits.

Pollination of English walnuts.

Nitrate studies with apples.

Fertilizer tests with strawberries.

Thinning investigations with apples.

Orchard economic studies with apples.

Investigations of stocks for pears.

Cover crop adaptability for Southern Oregon.

Methods of maintaining organic matter in sandy soil of the Columbia Basin.

Relations of harvesting and storing methods in maturity of pears.

Fertilizer investigations with onions.

Pollination of greenhouse tomatoes.

Variety tests with broccoli.

Value of various vegetables for cannery purposes.

Irrigation and fertilizer investigations with field grown tomatoes, cabbage, broccoli, and celery.

Standardization of the Italian prune.

Utilization of apple culls.

Canning values of leading commercial varieties of fruits.

Condensation and clarification of loganberry juice.

Utilization of the waste products from the horticultural product plants.

Smith-Lever and Other Funds.

Pruning demonstration.

Spraying demonstration.

TEXAS.

EXPERIMENT STATION, *College Station*.

Adams Fund.

Plant breeding, using blackberries, dewberries and raspberries, in efforts to produce a more desirable, spineless berry adapted to Texas conditions.

Hatch Fund.

Field studies on crown gall, with studies of control.

Longevity and adaptability of the Indian cling peach versus modern commercial varieties.

Studies of American vs. European varieties of grapes when grafted on to native (*Vitis champinii*) stock.

State and Federal Funds.

Rosaceous fruit breeding work conducted in co-operation with the Bureau of Plant Industry, at the Troup substation.

College Funds.

Variety test of roses.

A test of various pecan stocks.

Variety test of potatoes.

Smith-Lever Fund.

Fruit growing.

Vegetable growing.

Pecan propagation.

Fruit and vegetable diseases.

Orchard and garden insects.

Control of sweet potato weevil.

UTAH.

UTAH AGRICULTURAL COLLEGE, *Logan*.

State and Other Funds.

Canning crops.

Horticultural survey.

Breeding of horticultural plants.

Utilization of horticultural products.

VIRGINIA.

UNIVERSITY OF VIRGINIA, *Blacksburg*.

Adams Fund.

Effect of soil environment on fruit bud formation.

Effect of time of pruning on fruit bud formation.

Breeding late blooming apples.

Study of laws of inheritance of garden vegetables.

Hatch Fund.

Commercial value of dwarf apples.

Control of fire blight.

Varietal studies of tree fruits.

State Fund.

Orchards throughout the state for study of spraying, fertilizing, and soil management.

Smith-Lever Fund.

Demonstrations in orchard management, garden management, pruning, spraying, fire blight control, grading and packing fruit, mice eradication and bridge grafting to save mice injured trees.

TRUCK EXPERIMENT STATION, *Norfolk.*

Truck crop cultural investigations.
 Strain and variety tests of cabbage, potatoes and other vegetables.
 Sweet potato investigations, including cultural methods, seed storage and improvement by selections.
 Sweet potato disease investigations.
 Fertilizers and soil requirements for various vegetables.
 Effect of continued applications of various fertilizer ingredients and combinations on crop production, and their residual effect upon the soil.
 Peanut rotations.
 Cover crop and truck crop rotations.
 Control of diseases of spinach, sweet potatoes, Irish potatoes, egg plant, cucumbers, lettuce, beans, watermelons and peanuts.
 Vegetable storage and marketing studies.
 Insect and plant disease transmission.

WEST VIRGINIA.

UNIVERSITY OF WEST VIRGINIA, *Morgantown.*

Adams Fund.

Pollination of the apple to study self-sterility in certain varieties.
 Physiological effect of pruning apple and peach trees in varying amounts at various seasons. Metabolism of the apple has been carefully studied in this connection.

Hatch and State Funds.

Physiological effect of pruning cherry, plum, pear and quince trees.
 Apple orchard culture experiments.
 Effect of thinning fruit upon annual bearing of apples.
 Fertilizer for apple and peach trees of different ages.
 Variety test of tree fruits.
 Variety test and study of fertilizer and pruning requirements of bush fruits.
 A study of several factors influencing strawberry production, such as fertilizers, varieties and their adaption, systems of planting, and the effect of plant selection.
 General survey of the small fruit industry.
 Variety and fertilizer test, cultural methods, and effect of pruning on yield and vigor of grapes.
 Demonstrational co-operative orchard and variety testing work.
 Test of spray nozzles.
 Breeding of sweet potatoes to study the effect of hill selection on yield and vigor.
 Irish potato breeding to study the effect of bud selection; experiment conducted on the tuber unit.
 Potato cultural experiment to study the various factors affecting yield and vigor.

AMERICAN SOCIETY FOR HORTICULTURAL SCIENCE.

Potato variety test.

Improving poor soil by means of moderate applications of commercial fertilizers and manures and the use of cover crops while producing profitable truck crops.

Selection of carnation for high and low yield.

A varietal study of the snapdragon and a test of its value as a greenhouse cut flower for West Virginia conditions.

A study of hardy perennials suitable for West Virginia conditions.

Smith-Lever Fund.

Extension work in demonstrations on tree fruits, small fruits and vegetables, and the keeping of accurate records of costs, yields, etc.

Extension work by means of farmers' institutes, extension schools, correspondence courses, judging at district and county fairs, and special assistance to individuals.

Extension work in potato production.

Extension work in the organization of city, school and miners' garden movement.

WISCONSIN.

UNIVERSITY OF WISCONSIN, *Madison*.

Same as last year.

REPORT OF THE COMMITTEE ON RESOLUTIONS.

WHEREAS, at the annual smoker held on the evening of December 27, 1917, Dr. L. H. Bailey, President of the American Pomological Society, was invited to talk on subjects of his own choosing, delightfully entertained the members of American Society for Horticultural Science with an account of his recent collecting trip in China, and under suggestions for the good of the horticultural industry presented a plan for increasing the membership and interest in the American Pomological Society. Briefly the plan was to go after a large membership among amateur horticulturists, thus getting back to the original aims and principles of the Society. In order to hold the membership together it was suggested to establish a weekly or monthly journal to be sent free to members.

He urged his hearers to think the matter over during the next few months as nothing can be done—except possibly privately to establish the journal before the next annual meeting of the Pomological Society. It is therefore,

RESOLVED, That we go on record as being in sympathy with the suggestion of Dr. Bailey regarding his plans for improving the usefulness and increased interest in the American Pomological Society and hereby pledge ourselves as an organization and as individuals to assist in carrying them out when officially called upon to do so.

RESOLVED, That we tender our thanks to the authorities of the Carnegie Institute of Technology for supplying rooms in which to hold our meetings and excellent facilities and assistance for carrying out the various features of our program.

W. L. HOWARD,
J. H. GOURLEY,
J. C. BLAIR,

Committee. .

ANNUAL MEETING IN 1918.

It was decided to have the annual meeting in 1918 cover three days, and to hold one session jointly with Section M, Agriculture, of the American Association for the Advancement of Science.

DONATION TO THE FRENCH FRUIT FUND.

The Horticultural Society of New York has appealed to the several horticultural societies of this country to make donations to a fund to be used in the replanting of fruit trees in the devastated regions of France. Our members gladly voted \$100 for this purpose, and the Treasurer sent a check for this amount to Mr. F. R. Newbold, Treasurer of the Horticultural Society of New York. Mr. Newbold's letter of January 15, 1918, to the Secretary acknowledging receipt of this check is deeply interesting and is given herewith:

DEAR SIR:

I enclose receipt for your check for \$100, received today for which I deeply thank you. This fund has now reached \$3,612.48, and there are several entertainments to be given shortly by Garden Clubs and Horticultural Societies, the proceeds of which are to go to the fund, so that I hope to have between four and five thousand dollars by the end of the month.

We have arranged to have this money distributed in France under the auspices of the American Red Cross, but the actual work will be done by the American Fund for French Wounded, Civilian Relief Committee, who now represent and are doing this work for the Red Cross and French Government, in both the Somme and Aisne districts, with headquarters at Blarancourt.

The actual work of planting is done by French soldiers during their rest periods behind the lines.

The Committee in France have arranged to have the orchards marked with brass tags or plates with name of donor, so that later on when the work has been done, I hope to be able to send you a report stating exactly where your donation was expended. We have an option on some 90 thousand fruit trees in two or three nurseries in France, that deliver the trees at 60 cents each in the devastated regions by motor truck. In this way we hope we are helping both the French Nurserymen and the Refugees. All this work is done under the supervision of horticultural experts, appointed one by the French government, one by the National French Horticultural Society and one of our members working for the American Fund for French Wounded at Blarancourt. The cost of planting the orchards belonging to one village is from \$150 to \$300.

In a letter received from Blarancourt last autumn it is stated that in the Somme district alone about 175 thousand apple trees were destroyed.

A number of these have been or were replanted last year by the American Fund for French Wounded and the French Horticultural Society, and they also distributed some 60 thousand scions for grafting.

Believe me,

Very truly yours,

F. R. NEWBOLD,

Treasurer.



A. V STUBENRAUCH

OBITUARY.

Arnold Valentine Stubenrauch was born April 27, 1871, in New Orleans. He was prepared for college in the High School Department of Tulane University of Louisiana. In 1891 he entered the University of California, graduating from the College of Agriculture in 1899. During his under-graduate years he was secretary to Dr. Hilgard, Dean and Director of the Experiment Station. After graduation he was elected to a fellowship in horticulture in Cornell University, and in 1901 took the degree of Master of Science. From 1901 to 1902 he was instructor in horticulture at the University of Illinois, and from July, 1902, to January, 1906, Assistant Professor of Horticulture in the University of California.

In 1906 Professor Stubenrauch became associated with the U. S. Department of Agriculture in connection with their fruit transportation and storage investigations. In 1910 he was placed in charge of the field investigations in pomology, including investigations of fruit transportation and storage. In April, 1913, he was made pomologist in charge of horticultural and pomological investigations in the department.

In August, 1914, Professor Stubenrauch was called back to his Alma Mater, the University of California, to take charge of the newly created division of pomology, but at the same time continued to be consulting pomologist in the U. S. Department of Agriculture.

Professor Stubenrauch died at his home in Berkeley on February 12, 1917. He is survived by his wife, Marie Meyer Stubenrauch, and two sons, Arnold V. Stubenrauch and Paul Bailey Stubenrauch.

Professor Stubenrauch won fame for his investigations in the transportation and storage of California and Florida fruits. He determined the factors underlying the successful storage of California grapes and discovered the use of redwood sawdust as a packing material, and later, with C. W. Mann, introduced this method of handling and storing grapes into successful commercial practice, thereby making the Red Emperor grape a profitable variety.

His writing between the years 1895 and 1914, inclusive, include between forty-five and fifty titles.

Professor Stubenrauch was a member of the following societies: Sigma Xi, Alpha Zeta, Acacia Fraternity, American Association of Refrigeration, American Pomological Society, American Society for Horticultural Science, American Genetic Society, Washington Academy of Science, and fellow of the American Association for the Advancement of Science.

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C. A. McCUE

PROCEEDINGS
OF THE
American Society
FOR
Horticultural Science
1918

*Fifteenth Annual Meeting, Baltimore, Maryland
December 27 and 28, 1918*

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College Park, Maryland

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OFFICERS AND COMMITTEES FOR 1919

<i>President</i>	J. W. CROW
<i>Vice-Presidents</i>	J. P. STEWART
	E. J. KRAUS
	R. WELLINGTON
<i>Secretary-Treasurer</i>	C. P. CLOSE
<i>Assistant Treasurer</i>	C. E. DURST

EXECUTIVE COMMITTEE

W. H. CHANDLER, <i>Chairman</i>	J. W. CROW, President, <i>ex-officio</i>
C. A. McCUE	C. P. CLOSE, Secretary, <i>ex-officio</i>
	W. L. HOWARD

NOMINATING

C. H. CONNORS, <i>Chairman</i>	R. W. REES
R. H. ROBERTS	R. E. MARSHALL
	B. S. PICKETT

PROGRAM

J. K. SHAW, <i>Chairman</i>	C. P. CLOSE, Secretary, <i>ex-officio</i>
W. H. ALDERMAN	C. I. LEWIS
W. T. MACOUN	J. E. COIT

RESEARCH AND EXPERIMENTATION

T. C. JOHNSON, <i>Chairman</i>	E. J. KRAUS
	H. J. WEBBER

MEMBERSHIP

C. E. DURST, <i>Chairman</i>	J. E. COIT	T. C. JOHNSON
C. P. CLOSE	A. J. FARLEY	J. G. MOORE
G. C. STARCHER	R. W. REES	J. W. CROW

BOARD OF BOTANICAL ABSTRACTS

C. A. McCUE	E. J. KRAUS
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FEDERAL HORTICULTURAL BOARD RULINGS

W. R. BEATTIE	A. J. FARLEY	J. P. STEWART
---------------	--------------	---------------

MEMBER A. A. A. S. COUNCIL

C. P. CLOSE

CONSTITUTION

ARTICLE 1.

The name of this Association shall be the American Society for Horticultural Science.

ARTICLE 2.

The object of the Society shall be to promote the Science of Horticulture.

ARTICLE 3.

Any person who is a graduate of an agricultural college and holds an official position in an agricultural college, experiment station, or federal Department of Agriculture in the United States or Canada, may become a member upon payment of the annual dues of \$1.50.

ARTICLE 4.

Meetings shall be held annually at such time and place as may be designated by the Executive Committee, unless otherwise ordered by the Society.

ARTICLE 5.

The officers shall consist of a President, three Vice-Presidents, and a Secretary-Treasurer, who, together with the chairmen of the standing committees, shall constitute a Council to act upon all applications for membership. There shall also be an Assistant Secretary. These officers shall be elected annually by ballot.

ARTICLE 6.

This Constitution may be amended by two-thirds vote of the Society at any regular meeting, notice of such amendment having been read at the last regular meeting.

BY-LAWS

SECTION 1. The President and other officers shall perform the usual duties of their respective offices. The President shall also deliver an address at each regular meeting.

SEC. 2. There shall be a Committee on Nominations consisting of five (5) members, who shall be nominated and elected by ballot at each regular meeting of the Society. It shall be the duty of this committee, at the following meeting, to suggest to the Society names for officers, referees, and members of committees for the ensuing year.†

SEC. 3. There shall be an Executive Committee, consisting of three (3) members and the President and the Secretary, ex-officio. This committee shall perform the usual duties devolving upon such committee.

SEC. 4. The Committee on Nominations shall nominate referees and alternates upon special subjects of investigation or instruction, which may be referred to its consideration by the Society. The duties of these referees shall be to make concise reports upon recent investigations or methods of teaching in the subjects assigned them, and to report the present status of the same.

SEC. 5. There shall be a Committee on Program, consisting of seven (7) members, of which the Secretary shall be one. This committee shall have charge of the scientific activities of the Society, except as otherwise ordered by the Society.

SEC. 6. The annual dues of the Society shall be one dollar and fifty cents.

SEC. 7. Ten members of the Society shall constitute a quorum.

*The Constitution and By-Laws as amended from time to time.

†Since 1913 two lists of candidates have been required.

MEMBERSHIP ROLL FOR 1918

ALDERMAN, W. H.....Experiment Station, Morgantown, W. Va.
 ALLEN, F. W.....624 Miller Building, Yakima, Washington.
 ANDERSON, J. P.....Juneau, Alaska.
 ANDERSON, O. G.....Purdue University, Lafayette, Indiana.
 ANTHONY, R. D.....Experiment Station, Geneva, New York.
 AUCHTER, E. C.....Maryland State College, College Park, Maryland.

 BABCOCK, E. B.....University of California, Berkeley, California.
 BAILEY, E. W.....University of Illinois, Urbana, Illinois.
 BAILEY, L. H.....Ithaca, New York.
 BALLARD, W. R.....Experiment Station, College Park, Maryland.
 BARNETT, R. J.....State College of Washington, Pullman, Wash.
 BARRON, LEONARD....Garden City, New York.
 BARSS, A. F.....University of British Columbia, Vancouver, B. C.
 BATCHELOR, L. D.....Citrus Experiment Station, Riverside, California.
 BEACH, F. A.....Ohio State University, Columbus, Ohio.
 BEACH, S. A.....Iowa State College, Ames, Iowa.
 BEAL, A. C.....Cornell University, Ithaca, New York.
 BEATTIE, W. R.....U. S. Dept. Agr., Washington, D. C.
 BECHTEL, J. R.....Pennsylvania State College, State College, Pa.
 BECKENSTRATER, H...Maryland State College, College Park, Maryland.
 BENNETT, E. R.....Extension Service, Boise, Idaho.
 BIOLETTA, F. T.....University of California, Berkeley, California.
 BLAIR, J. C.....University of Illinois, Urbana, Illinois.
 BLAIR, W. S.....Experiment Station, Kentville, Nova Scotia.
 BLAKE, M. A.....Experiment Station, New Brunswick, N. J.
 BRIERLY, W. G.....University Farm, St. Paul, Minnesota.
 BROCK, W. S.....University of Illinois, Urbana, Illinois.
 BROWN, B. S.....University of Maine, Orono, Maine.
 BUCK, F. E.....Central Experimental Farm, Ottawa, Canada.

 CADY, LEROY.....University Farm, St. Paul, Minnesota.
 CALDWELL, J. S.....U. S. Dept. Agr., Washington, D. C.
 CHANDLER, W. H.....Cornell University, Ithaca, New York.
 CLARK, C. F.....U. S. Dept. Agr., Washington, D. C.
 CLEMENT, F. M.....University of British Columbia, Vancouver, B. C.
 CLOSE, C. P.....U. S. Dept. Agr., Washington, D. C.
 COIT, J. E.....357 Court House, Los Angeles, California.
 COLBY, A. S.....University of Illinois, Urbana, Illinois.
 CONDIT, I. J.....University of California, Berkeley, California
 CONNORS, C. H.....Experiment Station, New Brunswick, N. J.
 COOPER, J. R.....University of Arkansas, Fayetteville, Arkansas.
 CORBETT, L. C.....U. S. Dept. Agr., Washington, D. C.
 CORRIVEAU, P. E.....Agricultural College, Kingston, Rhode Island.
 CRAIG, A. G.....Arcadia Orchards Company, Deer Park, Wash.
 CRANDALL, C. S.....University of Illinois, Urbana, Illinois.
 CRIDER, F. J.....University of Arizona, Tucson, Arizona.
 CROW, J. W.....Agricultural College, Guelph, Canada.
 CRUICKSHANK, R. R...Ohio State University, Columbus, Ohio.
 CULLINAN, F. P.....Purdue University, Lafayette, Indiana.
 CULVERHOUSE, P. E...Hort. Experiment Sta., Vineland Sta., Ont., Can.
 CUMMINGS, M. B.....Experiment Station, Burlington, Vermont.

- DACY, A. L. Experiment Station, Morgantown, W. Va.
 DARROW, G. M. U. S. Dept. Agr., Washington, D. C.
 DAVIS, V. H. State Department of Agriculture, Columbus, Ohio.
 DEARING, CHARLES. . . . U. S. Dept. Agr., Washington, D. C.
 DETJEN, L. R. Experiment Station, West Raleigh, N. C.
 DICKENS, ALBERT. . . . Agricultural College, Manhattan, Kansas.
 DORSEY, M. J. University Farm, St. Paul, Minnesota.
 DRINKARD, JR., A. W. . . Experiment Station, Blacksburg, Virginia.
 DURST, C. E. Anna, Illinois.

 EDMISTER, A. F. U. S. Dept. Agr., Washington, D. C.
 ERWIN, A. T. Iowa State College, Ames, Iowa.
 EUSTACE, H. J. Agricultural College, East Lansing, Michigan.

 FAGAN, F. N. Experiment Station, State College, Pa.
 FARLEY, A. J. Experiment Station, New Brunswick, N. J.
 FISHER, D. F. Wenatchee, Washington.
 FLETCHER, S. W. Pennsylvania State College, State College, Pa.
 FLETCHER, W. F. Provo, Utah.
 FLOSSFEDER, F. University Farm School, Davis, California.
 FRENCH, P. E. Vernon, British Columbia.
 FROST, H. B. University of California, Berkeley, California.
 FLOYD, B. F. Experiment Station, Gainesville, Florida.

 GLADWIN, F. E. Vineland Laboratory, Fredonia, New York.
 GOODING, J. H. State College of Washington, Pullman, Wash.
 GOULD, H. P. U. S. Dept. Agr., Washington, D. C.
 GOURLEY, J. H. Agricultural College, Durham, New Hampshire.
 GREEN, L. Purdue University, Lafayette, Indiana.
 GUNDERSON, A. J. University of Illinois, Urbana, Ill.

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 HANSEN, N. E. Agricultural College, Brookings, South Dakota.
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 HEDRICK, U. P. Experiment Station, Geneva, New York.
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 HENDRICKSON, A. H. . . . Cornell University, Ithaca, New York.
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 HOLMES, F. S. Experiment Station, College Park, Md.
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 HOWARD, W. L. University Farm School, Davis, California.
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 KILHAM, A. D. Massachusetts Agr. College, Amherst, Mass.
 KIRKPATRICK, E. L. . . . Agricultural College, Fort Collins, Colorado.
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 KRAUS, E. J. Experiment Station, Corvallis, Oregon.
 KRAYBILL, H. R. U. S. Dept. Agr., Washington, D. C.
 KYLE, E. J. A. & M. College of Texas, College Station, Tex.

LAKE, E. R. U. S. Dept. Agr., Washington, D. C.
 LANHAM, W. B. A. & M. College of Texas, College Station, Tex.
 LAWRENCE, W. H. University of Missouri, Columbia, Missouri.
 LEHRENBauer, P. A. University of Illinois, Urbana, Ill.
 LEOPOLD, M. La Trappe, Quebec, Canada.
 LESLIE, W. R. Industrial Farm, Fort Williams, Ontario, Canada.
 LEWIS, C. I. Agricultural College, Corvallis, Oregon.
 LLOYD, J. W. University of Illinois, Urbana, Ill.
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 LOMMEL, W. E. Purdue University, Lafayette, Indiana.
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MACFARLANE, JAMES. Agricultural College, Durham, New Hampshire.
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 MACOUN, W. T. Central Experimental Farm, Ottawa, Canada.
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- WALKER, A. H. Macdonald College, Quebec, Canada.
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 WERNER, H. O. University of Nebraska, Lincoln, Nebraska.
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 WHIPPLE, O. B. Experiment Station, Bozeman, Montana.
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 WOODBURY, C. G. Purdue University, Lafayette, Indiana.
 WORK, PAUL. Cornell University, Ithaca, New York.
- YEAGER, A. F. Pennsylvania State College, State College, Pa.
- ZIMMERLEY, H. H. Virginia Truck Experiment Station, Norfolk, Va.

TREASURER'S REPORT FOR 1918

Voucher No.	Cr.		
1918.			
Jan. 4	Stamps	\$2.00	
Jan. 8	Stamps	2.00	
(1) Jan. 14	Expenses of Secretary in attending Pittsburgh Meeting	31.87	
(2) Jan. 14	The Horticultural Society of New York for the French Fruit Growers' Fund to be used in replanting the fruit orchards of France....	100.00	
(3) Jan. 22	C. A. McCue for stamps used by program committee in 1917.....	6.72	
Feb. 1	Stamps	2.00	
Feb. 7	Stamps	1.00	
(4) Feb. 9	Maurice Joyce Engraving Co., Inc.: 3 Zinc etchings for 1917 Report..... \$5.61 1 Half-tone for 1917 Report..... 2.93	8.54	
(4½) Feb. 26	Telephone to George T. Melvin, Annapolis, Md.	.35	
Feb. 28	Stamps	3.00	
(5) April 15	George T. Melvin, 3,000 letterheads and 2,750 envelopes	\$28.50	
	Parcel Post on same.....	.68	
		29.18	
April 25	Stamps	2.00	
(6) June 12	Express on 1917 Reports from Annapolis, Md.	2.31	
June 14	Stamps	6.00	
June 15	Postage on 1917 Reports.....	15.43	
June 20	Postage on 1917 Reports.....	2.67	
June 27	Stamps	1.00	
(7) July 8	George T. Melvin, 500 Report envelopes.....	5.85	
July 10	Stamps	1.00	
Oct. 24	Stamps	2.00	
(8) Nov. 15	George T. Melvin, printing 1917 Report.....	294.05	
Nov. 29	Stamps	2.00	
Dec. 4	Stamps	1.00	
Dec. 11	Stamps	2.00	
Dec. 17	Stamps	5.00	
Dec. 20	Torsch & Franz Badge Co., 1917 buttons.....	3.29	
		\$532.26	
1918.	Dr		
Jan. 2	By Balance on hand.....	\$500.11	
Jan. 7	Agricultural College of Utah, Logan, Utah, 1916 report	1.50	
Jan. 31	Leonard Barron, Garden City, N. Y., reports for 1915-16	2.50	
Feb. 16	University of Missouri, Columbia, Mo., 1916 report..	1.50	
Feb. 28	A. F. Edminster, U. S. Dept. Agr., reports 1915-16..	2.50	
May 28	G. E. Stechert & Co., New York City, 1916 report....	1.50	
June 24	American News Co., New York City, 1917 report....	1.50	
June 24	Experiment Station, Blacksburg, Va., 1917 report....	1.50	
July 5	Purdue University, Lafayette, Ind., 1917 report.....	1.50	
	University of Vermont, Burlington, Vt., 1917 report.	1.50	
	New Mexico College of Agr. & Mech. Arts, State College, N. M., 1917 report.....	1.50	

	Kentucky Agr. Exp. Sta., Lexington, Ky., 1917 report.	1.50
July 10	Brooklyn Institute of Arts and Sciences, Brooklyn, N. Y., 1917 report.....	1.50
July 18	R. Veterinary & Agr. College, Copenhagen, Denmark, 1917 report	1.50
July 19	G. E. Stechert & Co., New York City, 1917 report...	1.50
July 22	University of Minnesota, St. Paul, Minn., 1917 report	1.50
	Colorado Agr. College, Fort Collins, Colo., 1917 report	1.50
July 23	State College of Washington, Pullman, Wash., 1917 report	1.50
July 30	Iowa State College, Ames, Iowa, 1917 report.....	1.50
	University of Maine, Orono, Maine, 1917 report.....	1.50
Aug. 5	Experiment Station, Wooster, Ohio, 1917 report.....	1.50
Aug. 10	University of California, Berkeley, Cal., 2 reports for 1917 .	3.00
Aug. 17	Georgia State College of Agr., Athens, Ga., 1917 report	1.50
Aug. 20	Ohio State University, Columbus, Ohio, 1917 report..	1.50
	University of Missouri, Columbia, Mo., 1917 report..	1.50
	University of California, Berkeley, Cal., 1917 report.	1.50
	G. E. Stechert & Co., New York City, complete set of reports	14.00
Sept. 2	Louisiana State University, Baton Rouge, La., 1917 report	1.50
Sept. 11	Massachusetts Agr. College, Amherst, Mass., 1917 report	1.50
Oct. 7	New York Botanical Garden, New York City, complete set of reports.....	14.00
	University of Wisconsin, Madison, Wis., 1917 report.	1.50
	F. P. Cullinan, Purdue University, Lafayette, Ind., 1917 report	1.50
Nov. 4	United States Experiment Station, Honolulu, Hawaii, 1917 report	1.50
Nov. 20	Georgia Experiment Station, Experiment, Ga., 1917 report	1.50
	Southern Oregon Experiment Station, Talent, Ore., 1917 report	1.50
Nov. 23	G. E. Stechert & Co., New York City, complete set of reports	14.00
Nov. 26	The Baker & Taylor Co., New York City, reports 1916 and 1917.....	3.00
Dec. 14	University of Nebraska, Lincoln, Neb., 1917 report..	1.50
	John Joseph McVey, Philadelphia, Pa., complete set of reports	14.00
Dec. 26	Package Sales Corporation, South Bend, Ind., 1917 report	1.50
	Membership dues paid.....	331.50
		\$945.11
Balance on hand.....		
		\$412.85

Respectfully submitted,
C. P. CLOSE, Treasurer.

The Auditing Committee reported that it had examined the accounts of the Treasurer and found them to be correct.

J. P. STEWART,
A. H. HENDRICKSON,
A. G. GUNDERSON,
Auditing Committee.

ANNUAL MEETING AT BALTIMORE, MD., 1918

FRIDAY, DECEMBER 27, 9:30 A. M.

President McCue called the meeting to order and presided over all of the sessions. About 40 members were in attendance during the meeting though not all at any one session. The discussions were full of snap and vigor and the meeting was one of the best we have ever had. It was unfortunate that more of the members were not present.

WINTER INJURY IN CANADA.

By W. T. MACCOUN, *Central Experimental Farm,*
OTTAWA, CANADA.

During the past sixty years, beyond which commercial orchards were of small extent in Canada, there have been seven winters which have caused heavy losses among fruit trees in the Provinces of Ontario and Quebec. These were the winters of 1858-9, 1876-7, 1884-5, 1895-6, 1898-9, 1903-4, and 1917-18. Of these the winters of 1884-5, 1895-6 and 1898-9 were winters with little or no snow on the ground in the middle of winter, and root killing was the principal form of injury. During the past twenty years the two winters which have been most destructive were those of 1903-4 and 1917-18, and in neither of these winters did trees suffer from root killing in Eastern Ontario and the Province of Quebec, as there was a heavy covering of snow. There were 306 apple trees, including 164 varieties, killed in the orchards of the Experimental Farm, Ottawaa, by the winter of 1903-4; and by the winter of 1917-18 there were 360 trees killed, including 200 varieties; and it is expected more will be dead in the spring of 1918-19 as a result of that winter.

The winters of 1903-4 and 1917-18 were somewhat similar in that there were long spells of very cold weather with a drop to below -20°F. in December. In 1903-4 the temperature fell to -23.2°F. on December 15; in 1917-18 it was -25°F. on December 12. The coldest day of the winter of 1903-4 was -30.2°F. on Jan. 5; the coldest day of 1917-18 was December 30, 1917, when the temperature was -30.8°F. It was below zero on 58 days in the winter of 1903-4 and on 55 days in the winter of 1917-18. The mean temperature from November 1st, 1903, to April 1st, 1904, was $+14.68^{\circ}$, and for the same period in 1917-18, it was $+14.84^{\circ}$. There were three months in both these winters with no real thaws, although the temperature rose a few degrees above freezing on several days during the winter.

The lowest temperature in November, 1903, was -0.1°F. on the 26th. The lowest in 1917 in November was -8°F. on the

27th. While 1917 was a short growing season, this cannot be said of the season of 1903-4. It was an early spring, and it is recorded in our diary that "September and October were fine and fruits and vegetables matured well." The autumn of 1917 was considered favorable on the whole for the ripening of the wood of apple trees, although October was not as bright as usual. We have a note in our diary on November 19, 1917, that "it (November) has been a very fine month so far, the finest November since farm records were taken. No precipitation of any kind, and mild on the whole." The conditions seemed very favorable for the trees wintering well at that date.

We have two clues as to the dates between which most of the injury occurred in the winter of 1917-18. Each year scions of a large number of varieties of apples are taken for root grafting. The first lot of scions was taken from trees in the orchards at Ottawa on December 5 and 6, 1917, and on account of the practically continuous cold weather, no more scions were taken until February, 13, 1918. The first lot was cut and grafted without any injury to scions having been noticed. On cutting the second lot of scions it was noticed that a large proportion of them had been injured; the pith was brown. The results from the grafting are interesting. The records of one page of the grafting books of scions cut before and after injury follows:

Root grafted.....Winter 1917-18	Root grafted.....Winter 1917-18
Scions taken....Dec. 5 and 6, 1917	Scions taken.....Feb. 13, 1918
Stock.....Seedlings of Orion Crab	Stock....Seedlings of Martha Crab
24 Varieties.	22 Varieties.

Number of grafts made.....885	Number of grafts made.....607
Number of grafts grew.....559	Number of grafts grew.....112
Percentage of grafts grew....63.16	Percentage of grafts grew....18.45

Compare both of these with results from root grafting in the winter of 1916-17, taking the record of one page of the grafting book—25 varieties.

Number of grafts made: 1583.

Number of grafts grew: 1362.

Percentage of grafts grew: 86.03.

The stock was seedlings of Excelsior crab. The same man made all the grafts.

This was, however, not a planned experiment, and while the results are very suggestive, the kind of stock and the time of grafting may have had something to do with the differences; though judging by past experience, we must conclude that most of the difference is due to winter injury.

The next clue as to the time the winter injury occurred is obtained from the notes made on each individual tree of the 360 apple trees which were killed in the winter of 1917-18 at Ottawa. A record was not made of how low down every tree was killed, but in the great majority of cases the trunk was killed to the ground, or to within about 18 inches of the ground. This would

seem to indicate that the trunk was not protected by snow, or but little protected by snow, when the injury occurred, again putting the time of injury before February 13, by which time there had fallen 90 inches of snow. Only 24 inches of this fell before December 12, the date of the first very low temperature. The snowfall in November was 10.50 inches; in December, 27.00 inches; in January, 31.50 inches; in February, 23.75 inches; and as the highest temperature in December was $+37.8^{\circ}$, and in January it never rose above freezing—nor did it in February before the 13th—there was little thawing. The coldest periods in the winter of 1917-18 were December 10-18, December 26—January 6, January 24—February 11, February 16-23. The total snowfall of the winter was 115 inches.

The injury to nursery stock was very great. On May 30 and 31, by which time growth was sufficiently advanced to be sure of how far back the trees were killed, notes were taken on each variety of the three year old stock. The notes were made of the approximate proportion of the tree which was killed, from the tips back.

Notes were made on 319 lots of trees, in which were included over 300 varieties.

PERCENTAGE OF WINTER INJURY TO THREE-YEAR-OLD APPLE TREES IN NURSERY.

Killed to near ground.....	7.52 per cent.
Killed back 75 per cent.....	19.12 per cent.
Killed back 66 per cent.....	3.76 per cent.
Killed back 50 per cent.....	17.87 per cent.
Killed back 33 per cent.....	13.48 per cent.
Killed back 25 per cent.....	8.47 per cent.
Tips killed back.....	18.81 per cent.
Not killed back.....	10.97 per cent.
	100.00 per cent.

Of the varieties which did not kill back at all 60 per cent were crab apple hybrids.

In 1912 the writer investigated the injury to nursery stock from autumn frosts in the nurseries of British Columbia where in some parts they are very subject to sharp frosts while the wood of the trees is still very unripe and the leaves green. The following notes were taken on October 24, 1912, on two year old trees which had been dug after 13°F. of Frost and stored in a cellar.

10 Esopus Spitzenburg,—all showed discoloration just below the cambium (within a foot from the ground) and one of these showed slight bursting of bark.

10 Yellow Newton,—all showed discoloration from base of trunk to one foot up.

10 Northern Spy,—9 had no discoloration. 1 showed slight discoloration.

10 Wealthy,—none showed discoloration.

10 McIntosh,—9, no discoloration, 1 slight, and bark raised a little.

Trees were examined in nursery where 12 Wagener trees showed discoloration within one foot of ground. In another nursery the only variety which showed discoloration after nine degrees F. of frost was Yellow Newtown. In another nursery where there had been 22°F. of frost on November 12, the previous year yearling trees had been badly injured being killed back or black hearted. In 1915 an apple orchard was set out at the Experimental Station, Lennoxville, Quebec. The trees grew late, and 13°F. of frost on October 25 caused the bark of the trunk of a number of trees to burst. These examples of injury to nursery stock are given to show that injury to the wood occurs even in autumn before very heavy frosts.

From our observations there are various stages of discoloration, from a slight browning just beneath the cambium to browning of the whole sap wood, or season's growth, the cambium still remaining alive. Yet again the injury is so great that the cambium is killed and there is complete killing back. Young trees growing vigorously may have the young wood discolored by frost year after year and yet not be killed back.

It may be that the scions taken on December 5th and 6th, 1917, had been injured to some extent by the 8° below zero in November, as much less frost than this, as has been shown, causes injury. Returning to the injury to the apple trees in the orchards at the Experimental Farm, Ottawa, trees from twenty-five to thirty years planted of such hardy varieties as Oldenburg Antonovka, Wealthy, Haas, and others were killed, but in all cases except one these trees had borne a good crop of fruit in 1917. In the case of tenderer varieties, such as Scott Winter, Roseau (Red Canada), McIntosh, Wolf River, and others, trees

Variety	Row and Tree	How affected by the Winter of 1917-18	Yield, 1917
Wealthy	Row 8... Tree 1 & 2		
"	" 8... " 3	No killing back	No crop
"	" 8... " 4	Killed	42 gallons
"	" 8... " 5	No killing back	3 gallons
"	" 8... " 6	Killed	33 gallons
"	" 8... " 7	No killing back	3 gallons
"	" 8... " 8	Badly injured	45 gallons
"	" 8... " 9	Died in a previous year	
"	" 8... " 10	Badly injured	35 gallons
"	" 8... " 11	Badly injured	16 gallons
"	" 8... " 12	Killed	30 gallons
"	" 8... " 13	No killing back	10 gallons
"	" 8... " 14	Killed	19 gallons
"	" 8... " 15	No killing back	No crop
"	" 8... " 16	Killed	27 gallons
"	" 8... " 17	No killing back	No crop

of bearing age which had borne light crops the previous year, were killed, although some of those killed had borne good crops, and other varieties evidently tenderer had borne no fruit in 1917.

Returning again to the Wealthy apple of which there are more trees at the Experimental Farm than of any other variety, taking one row of trees planted in 1896, it is interesting to note the relation of winter killing to the crop of the previous year. This was an outside row on the north side of the orchard. Tree 1 had died some years before, and tree 2 was in bad condition before winter, so they are not included.

Thus of 14 trees, the eight which bore a medium to good crop in 1917 were either killed or badly injured, while the six which had either a light crop or no crop, all came through in good condition. This outside row on the north side suffered much more than any other, as there were only three trees out of the remaining seven rows that were killed.

Following is the condition of trees in another row of Wealthy planted in 1909 on a rather low, moist piece of ground. Trees 1 to 11 were not killed back, and are marked as wintering well. They had borne crops of 1, 1, 1½, 12, 1, 0, 0, 3, 2 and 1, gallons in 1917.—all light crops except one. The remaining seven trees were as follows:

Variety	Row and Tree	How affected by the Winter of 1917-18	Yield, 1917
Wealthy	Row 3.....Tree 12	Not killed back	5 gallons
"	" 3..... " 13	Killed	20 gallons
"	" 3..... " 14	Not killed back	2 apples
"	" 3..... " 15	Killed	1½ gals.
"	" 3..... " 16	Not killed back	3½ gals.
"	" 3..... " 17	Killed	1 gal.

In this group of six trees only one tree had a good crop, and this was killed, but two others with light crops in 1917 were killed also. As already stated these trees were on low ground, the ground being lowest from tree 12 to 18, where winter injury occurred. One could obtain more evidence in these orchards to show that trees on low ground were more subject to winter killing than on the higher ground.

Nearly all the domestic plums were killed or badly injured, but few of the American varieties were affected, and these bore a good crop in 1918. Russian pears such as Bessemianka and Kurskaya, which had stood the winter of 1903-4, were badly injured. The few Morello cherry trees in the orchard were killed.

While the injury at Ottawa was confined to the killing of top and trunk, no root killing having been noticed, in other parts of Ontario there was root killing, splitting at the collar, bark splitting, and crotch injury.

WINTER INJURY IN NEW YORK STATE DURING 1917-18.

• By W. H. CHANDLER, *Cornell University, Ithaca, N. Y.*

Before beginning a discussion of the injury that occurred during the winter under consideration, brief mention should be made, both of the nature of the preceding summer and of the winter. The growing season of 1917 was one of the shortest on record. Thus while at Ithaca, New York, fruit trees will generally have reached full bloom by the middle of May or earlier, full bloom of the apple on that year was from June 3-5, of the peach from June 2-4, and of the pear from May 28—June 1. Yet there was a very heavy frost on September 23, and freezes by October 10 that killed the foliage on many fruit trees, including some of the apples. The season was thus at least three weeks shorter than normal. In addition to that the temperature throughout most of the summer in many sections was below normal, and the rainfall very heavy. Thus the wood went into winter in a poorly ripened condition. The winter itself was of course extremely cold and the duration of the cold periods was great. It is possible that the feature of the winter that deserves most consideration is the fact that the extreme cold came early (December 30). I have shown elsewhere that there seems to be a gradual increasing of hardiness through the winter. It seems then that since this cold period came early, it did more harm than it would have done had it come as late as February. The weather was below freezing during nearly all of December. Unless the ripening process can proceed while the wood is frozen, there could have been little increased hardiness during the month of December.

During the summer of 1918 most of the sections of New York were visited and the effect of the preceding winter on the fruit trees noted. Of the countries visited, Niagara, Orleans, and Monroe, along the southern side of Lake Ontario, had the least severe weather. The minimum temperatures of the sections nearest the lake ranged from about -7° to -12°F. , and in this section these lowest temperatures were reached in February instead of in December. In these three counties the peach wood was sufficiently injured, that in very many cases, perhaps in the majority of cases, the growth during 1918 was somewhat weak. Some of the buds were killed, but not nearly all. The small crop of fruit was due as largely to the fact that very few buds had been formed the season before as to the winter-killing. In fact, if there had been a normal set of buds it is probable that there would have been nearly a normal crop. So far as observations indicated, the tenderest tree and wood and bud was the J. H. Hale. The new variety, Rochester, had very little injury to the wood, and set the heaviest crop observed in the state during the year. There was a considerable amount of injury to the sapwood of pear trees, particularly the wood of the spurs. The thicker the spurs had grown during the summer of 1917, the greater the injury. Throughout the three counties, a small amount of killing of the sapwood in the

spurs was to be observed in the case of Baldwin, Greening, and Tompkins King apples. At one orchard near Madina, New York, Hubbardston apple trees in good condition except that they had borne a heavy crop in 1917, were seriously injured, some of them almost entirely killed. In Wayne County, one of the four excellent fruit counties along the Great Lakes, the temperatures were lower, ranging, so far as we could learn, around -20°F . The same or slightly lower minimum temperatures prevailed in some of the other counties in Western New York, particularly Ontario. Here peach trees were badly killed, some excellent orchards being entirely ruined. The older the trees, and the heavier the crop in 1917, apparently the worse the injury. One, two and three-year-old trees generally recovered rather well. Sweet cherry trees appeared to be in better condition when they first started growth in the spring, but later showed serious injury. In fact, they were but slightly hardier than peach trees. A very large percentage of the sweet cherry fruit buds also were killed. In case of quinces, there was much killing out of the twigs, but apparently the older wood was not seriously injured. Angouleme pear trees were very largely killed, and Bartlett, Bosc, and Kieffer, very badly injured, particularly in the sapwood of all parts. There was much injury to the wood of both young and old trees of Baldwin, Rhode Island Greening, Tompkins King and Hubbardston apples, Baldwin generally suffering the worst. In the case of old trees, however, there were many instances where trees of one of these other varieties suffered worse than Baldwin, provided the 1917 crop was heavier. The Ben Davis, Northern Spy, and Twenty Ounce seldom were injured in this section. At Ithaca, the temperatures were four or five degrees lower than in the section just discussed. Peach trees were injured of course more severely, in fact the wood was entirely black and there was much browning in the bark. It seemed impossible for any growth to start from such trees, and yet less than 20 per cent of the trees failed to make a considerable amount of growth, and more than half of them seem worth retaining. Trees in this condition made very much more growth and in every way recovered much better when fertilized early in the spring with about four pounds of nitrate of soda to the mature tree. While the sweet cherry trees did not show quite so much browning in the wood and started growth better in the spring, more than half of them died during the summer. The permanent loss was thus greater than with peach trees. More than 75 per cent of the flower buds were killed. Of the hybrids between the sweet and sour cherries observed, Reine Hortense and May Duke showed some injury, with a resulting weak 1918 growth, while Eugenia was not injured in the least. The injury to pears was slightly worse than that described for the above section, but not a large number of trees was entirely killed. There was injury to Wickson and a few other unimportant triflora plums, but none to wood or buds of Burbank or Abundance. There was some wood injury to Bradshaw, and a considerable number of buds were killed in case

of Reine Claude; but domestica plums were generally only slightly injured. The injury to apple trees was slightly worse than that mentioned for the sections above. In addition to the varieties there discussed, there was slight injury to Jonathan and Red Canada wood, though not enough to be of importance. Wood of Esopus, Stayman Winesap, Fall Pippin, Fallawater, and Winesap was rather seriously injured, but except in case of Fall Pippin not so badly as Baldwin, Greening and Tompkins King. The rainfall in this section was very heavy practically throughout the summer before, and particularly in late summer; and in case of both apples and pears anything that favored growth increased tenderness. Thus young trees in soil so wet that they made no growth came through the winter in better condition than trees in well drained soil. The latter of course made exceptional growth. In this section there was sometimes killing of the bark in the crotches of six to ten-year-old Northern Spy trees; but there was little or no injury to Ben Davis, Winter Banana, Wealthy, Twenty Ounce, Fameuse, McIntosh, Oldenburg, or other Russian varieties, or to any of the *Pyrus baccata* x *Pyrus malus* hybrids. Of course there were other varieties also that were uninjured. In Oswego County the temperatures seemed slightly lower than those at Ithaca, and the injury was perhaps slightly worse. The crotch injury to the Northern Spy trees was very serious, and both Northern Spy and Wealthy trees that had borne heavily in 1917 were badly injured. Many large Baldwin orchards were entirely killed. In the Champlain region and some adjacent counties the temperatures were -30°F. , and sometimes a few degrees lower. Here even the Fameuse apple, where the trees had borne heavily in 1917, was badly killed. The same was true of Wealthy and Northern Spy. The Ben Davis killed very badly here. The killing seemed worse in the sapwood toward the base of the branches, not being nearly so bad in the twigs or spurs as in the case of the Baldwin and Rhode Island Greening. Fameuse proved decidedly less hardy in case of both old and young trees than McIntosh. Only the slightest injury in the spurs was observed in McIntosh, and none was observed in the case of Oldenburg. In the Hudson River section the temperatures were about as low as those in Wayne and Ontario counties, but the injury to apples, pears, and peaches was decidedly less. An exception might be made in the case of the Baldwin apple. In the Hudson River section many trees of the Baldwin bore a heavy crop in 1917, and these were badly injured. Unlike most of New York, the weather of this section was very dry during late summer and autumn of 1917. This probably explains the greater hardiness of the wood. In very sandy land in this section, there was much killing of the roots of both pears and apples. Trees so injured would generally make a good start and then suddenly die. The only seriously injured McIntosh trees found in the state were those in this section, where the roots had been killed.

A brief discussion in a general way concerning the nature of the injury observed would seem worth while. As to the tissues most readily killed under average conditions the first was the sap wood as suggested above in some varieties notably Rhode Island Greening apple and nearly all pears. The tenderest sap wood was found in the spurs. In the warmer sections this was certainly true of most apple varieties. On the other hand, the sap wood of Ben Davis was most tender near the base of the branches. In case of those trees where the sap wood in the spurs and twigs was injured worse there was nearly always marked improvement during the summer with starting of vigorous growth some distance back from the ends of the small branches. In the case of Ben Davis, however, where the injury was at the base of the branches the beginning foliage was not small like that of the trees with the sap wood injury in the spurs, but was practically normal. The foliage, however, suddenly wilted later in the summer, thus instead of improvement as shown by the others there was sudden death or at least very marked decline. In the case of the larger branches the injury to the older layers of sap wood was greater than that to the younger layers, say 1916 and 1917 growth. Trees with sap wood injury only, except in case of Ben Davis just mentioned nearly always showed marked improvement as the season advanced probably following the formation of the new sap wood. It would seem probable that even more marked improvement might be expected next year. The bark is generally more hardy than the sap wood, exceptions, however, are found in the case of the bark at the base and on the inner side of the branches of five to ten-year-old trees and on the trunk of medium young trees. In case of trees that have borne heavy crops sometimes the bark was also killed in long strips on the upper side of a branch that had bent badly under the 1917 load. The cambium, while most tender in the growing condition, is much the most resistant when dormant, thus peach trees with the sap wood entirely black in the spring and with much browning in the bark still recovered, some of them making four or five feet of growth. It seems that the latest formed sap wood and bark that is not yet fully differentiated is also killed. In fact observation in the spring indicated that everything was killed. Of course the extremely thin cambium layer is not readily observed. Very often, when the bark was killed in the crotches and on the trunks and inner sides of large branches it was later found that the cambium had not been killed and new bark was forming underneath the dead bark. It would seem probable, then, that the removal of the dead bark from trunk and branches should be delayed until toward the end of the season's growth. Then, if the cambium had not been killed serious wounds would be avoided.

So far as results of this winter indicate the peach in wood is of course our most tender northern fruit. In this relation it is interesting to observe that the apricot is not very tender. Apricot trees were uninjured at Ithaca, though the fruits mentioned un-

der the discussion of that section were badly injured. A considerable number of apricot buds also came through the winter uninjured. The sweet cherry is in wood but slightly more hardy than the peach and it does not show the remarkable ability to recover after much of the wood has been killed that the peach shows. The sap wood of many varieties of pears is but slightly more resistant than that of the peach, but like the peach the pear shows great ability to recover when much of the wood has been killed. Thus, pear trees whose sap wood seemed entirely blackened, ripened good crops of fruit of normal size. Domestic plums were killed in the colder parts of the state (Clinton County) and some varieties of triflora plums were also injured. However, Burbank plums were not found injured in wood or bud in any part of the state. It is interesting to observe that on preceding winters, when the summer before had been drier and longer, Burbank plums had been largely killed even though the temperature had not been nearly so low. A few sour cherry trees in wet land were killed, but no wood injury and but little bud injury were observed this state where the trees were grown in well drained soil. The apple varied in hardiness from but slightly more than that of the peach in the case of Baldwin to a resistance equal to that of any fruit grown in the state except gooseberries and currants in case of McIntosh, Oldenburg and others. While blackberries showed a considerable amount of injury it was less than that on preceding years. The same was true of black raspberries and purple cane varieties, while red raspberries showed less injury than on any other year under my observation in the state. As to hardy varieties little was learned concerning the peach except that the new Rochester peach is one of the most hardy in wood and bud and the J. H. Hale is seldom if ever more hardy than Elberta, and is sometimes less hardy. Of the sweet cherries Schmidt seemed slightly more resistant than others; the same seemed true of Governor Wood. The most tender pears were Angouleme, Bartlett, Bosc, Clairgeau and Kieffer. The most resistant Flemish Beauty, Anjou and Sheldon. Clapp Favorite is appreciably more resistant than Bartlett except for its susceptibility to injury to the bark on the trunk and at the base of the branches. Baldwin, Rhode Island Greening, Tompkins King, Hubbardston, Gravenstein, Fall Pippin, Esopus, and Stayman Winesap are among the more tender varieties of apples. Ben Davis, Northern Spy, Red Canada, Jonathan, Wagener, Twenty Ounce are appreciably more resistant than the varieties of the first list, while Wealthy and Fameuse, when they have fruited heavily at least are less resistant than McIntosh, Oldenburg and some other Russian varieties that could be named.

In the case of the buds we know that the killing occurs on a single night and death can be observed soon after the buds have thawed. In case of the wood we also know that it can be killed by a single freezing of a few hours. If the temperature fall be rapid the killing will occur at a temperature well above those observed during the past winter. Whether the length of the cold

period influences the amount of killing we cannot say with certainty. I do know that within a few weeks after the cold night of December 30, certainly before our Farmers' Week of February 11, the characteristic browning was observed in the wood. That the temperature reached on a single cold night was the determining factor seems probable, otherwise the effects of air drainage should not be so marked, since the average temperature at the slightly higher elevation would probably be as low as that in the valley. The difference in the amount of killing in, let us say Niagara and Wayne Counties, seems to be explained by the difference of temperature on a single night. Thus, on the night of December 30 there was cloudiness near the lake in Niagara, but not in Wayne County, and the temperature for that night went lower in Wayne County. At South Hero, on Lake Champlain, the killing of Baldwin and Greening apples was very bad, while at Essex, on the west shore of the Lake there was almost no injury. It does not seem probable that there could be a difference in temperature through a long period, though there could have been for a single night.

In the maturity of the wood that results in its increased resistance it seems well to emphasize the importance of the foliage. In every case observed where the leaves had been removed in early or late summer by insects or spray burning there was serious killing of the wood. In high headed young trees the trunks, near the base, (farthest from the foliage) were most seriously injured. An excellent example was observed in the case of an orchard belonging to Mr. George Morse in Wayne County. Some high-headed Northern Spy trees about ten years old were top-worked in 1916 to Hubbardston. During the summer of 1917 the remaining Spy branches were removed from a part of these trees. In case of these where the high branches had not been removed and where the foliage would be thus larger no injury was observed. In case of the other trees, however, while the Hubbardston top was in all cases uninjured, the trunk showed much injury. This injury was much the greater at the base of the trunk and was less serious higher on the trunk towards the foliage. In a few cases the removal of a branch plainly resulted in the killing of the bark on the trunk or branch from which it had been removed, the removal having occurred during the spring of 1917. The inner portion of a branch nearly always contains less foliage and both bark and wood are nearly always less resistant. In all orchards observed, branches on the old trees which had been so shaded that they contained foliage only on weak twigs at the extreme ends, were killed even when the remaining branches were uninjured. All these observations indicate that something must come from the foliage during late season that results in a change, perhaps in the nature of the protoplasm such that it becomes more resistant to freezing. The effect of a heavy 1917 crop on resistance seems to throw light upon this subject. In numerous orchards throughout the state trees that bore a heavy crop during 1917 were killed en-

tirely or injured very badly while adjacent trees of the same variety and growing under the same conditions, but having their off year in 1917, were uninjured. It seems then that the fruit must have taken something that would have gone from the foliage to ripen the wood. That the inner sap wood furthest from the phloem containing the downward moving material which has been elaborated in the leaves should be more tender than that near the surface seems in line with this theory. It would seem that the material from the leaves which ripens the wood would more slowly reach this inner sap wood.

WINTER INJURY TO FRUIT TREES IN NEW JERSEY.

By M. A. BLAKE, *Experiment Station, New Brunswick, N. J.*

The winter of 1917-18 was the most severe experienced in New Jersey since official records have been kept. A light snow the latter part of November was followed by a "cold wave" and temperatures below normal prevailed for weeks. As soon as weather conditions became favorable to growth of plants the form and extent of winter injuries became apparent. The flower buds of peach trees were completely killed in counties north of Middlesex, except in a few well elevated orchards in northern Mercer and Monmouth counties. Along the coast in Monmouth county enough buds remained alive for a fair crop of peaches, but inland a short distance the crop was a failure. In Burlington county and south the percentage of bud killing was very low and later it was necessary to do considerable thinning of the fruit. No bud killing was observed upon either pears or apples anywhere in the state.

Bud killing was almost complete upon the Wickson plum at the Experiment Station at New Brunswick, but several hardy seedlings from the South Dakota Experiment Station bloomed freely. Cane fruits suffered considerable injury in central and northern New Jersey. Among varieties of blackberries at the Experiment Station, Snyder showed the least injury.

A slight amount of bark splitting occurred upon the trunks of apple and peach trees throughout the state. Gravenstein appeared to be the variety of apple most affected.

The most severe form of winter injury occurred to peach trees and was of an unusual nature. As the trees started to put forth into leaf they were often too yellow in color and some trees immediately died. An examination of these showed that the bark was killed upon the main root and upon the side roots to a depth of 12 to 18 inches and outward from the center to from 12 to 24 inches. Injury to the bark of peach trees about the collar and upon the main root is not uncommon in New Jersey, but root killing of the form and extent described has never been noted previously by the horticulturist.

This form of injury occurred as far south as Cumberland county where bud injury was negligible. The trees which were killed were mostly upon the very light sandy soil types and upon

knolls or dry areas. It was apparently the result of "dry freezing" of the bark and roots near the surface of the ground.

Injuries of a similar nature occurred to apple trees to a much less degree. Varieties such as Gravenstein, Tompkins King, Grimes and Baldwin suffered most. The injury to apples was not confined to the light soil types, but was equally severe upon the medium loam soils.

Collar injury of the usual type was also prevalent upon apples.

It is the observation of the writer that the varieties of peaches and apples which suffer most from collar rot and root injury near the trunk are those which are easily excited into growth during warm periods in winter and which make an early start in spring.

This is typical of Elberta among peaches and it is one which suffers severely from collar injury in New Jersey while Carman is relatively immune.

Gravenstein, Tompkins King and Baldwin are varieties of apple that are easily excited into vegetative activity and they are among the most susceptible to collar injury. The Northern Spy has been known to be a good stock to resist such injuries and it is one of the latest to start growth and to bloom.

It is believed that if our commercial varieties of peaches were propagated upon late starting, white fleshed stock, there would be a marked reduction in collar and root injury. There is no question either about the desirability of having such varieties of apples as Gravenstein, Tompkins King, Grimes and Baldwin propagated upon a late starting stock such as Northern Spy and this stock root should be long enough and planted so that it extends to a point several inches above the surface of the soil.

It is well to have hardy tops upon our fruit trees, but the past winter also demonstrated the need of hardy roots.

WINTER INJURY IN INDIANA.

By JOSEPH OSKAMP, *Experiment Station, Lafayette, Ind.*

THE APPLE.

The winter of 1917-18 was the first time on record that apple trees in Indiana have been so generally injured by low temperatures. The killing was largely in the bark and sapwood of the trunks and main limbs on the southwest side of the trees and was particularly bad in the crotches. Trees from three to fourteen years old suffered most, although the loss for the state as a whole is probably not over three per cent in trees of this age. The loss in old orchards is still less.

There are so many factors contributing to winter injury that it is many times impossible to explain why certain trees killed and others did not. Eliminating the anomalies it is possible to arrive at certain truths by considering a great number of cases. One of the outstanding factors contributing to winter injury was the

temperature as influenced by elevation. The low spots invariably experienced the greater killing. In traveling over the state one could not help but be impressed by the frequency with which certain varieties were damaged. Baldwin, Stayman Winesap, Ben Davis, Northern Spy, York Imperial and Jonathan suffered most, about in the order mentioned. Northwestern Greening and Delicious on the other hand stood the winter perfectly. Other varieties such as Grimes Golden, Winesap and Rome Beauty showed some isolated cases of injury, but not sufficient to consider them as at all tender. The condition of the trees was also a contributing factor and as innumerable things such as season, culture, pruning, fertilization, parasites, root stock, fruiting, etc., may affect the condition of the trees, there was ample opportunity for a wide variation in response. In this state the summer preceding was such as to make for greater tenderness. The season was short, cool and wet and it is probable many trees failed to properly ripen their wood, hence the killing in the trunk and main branches which would be the last to mature. The earliness of the extreme cold probably augmented the damage due to immaturity. Temperatures as low as that prevailing the past winter have been experienced in this state before, without severe injury to orchards. It will be worth while here to include a brief summarized statement of weekly minimum temperatures experienced on the Laurel Upland plots during the winters of 1911-12 and 1917-18. From Table I it can be seen that the minimum temperature was even

TABLE I.

Weekly Minimum Temperatures—Laurel Upland Plots.

WEEK ENDING	WINTER OF	
	1911-12	1917-18
December 10.. .. .	+13°F	-10°F
“ 17.. .. .	+27	-24*
“ 24.. .. .	+25	-2
“ 31.. .. .	+11	-16
January 7.. .. .	-10	-8
“ 14.. .. .	-25*	-18
“ 21.. .. .	-12	-24
“ 28.. .. .	+13	-15
February 4.. .. .	-14	-10
“ 11.. .. .	-12	-12

*Occurrence of minimum temperature of the winter.

one degree lower during the winter of 1911-12. In 1917-18 however the coldest temperature of the winter occurred about one month earlier or in mid-December. The month was also characterized by low temperatures generally, which with accompanying

clear weather would make extreme differences between the day and night temperature of the tree body.

As an example of the importance of the condition of the tree in interpreting winter injury phenomena, an experience in our Orchard Soil Management Experiment at Laurel may be cited. The major plots are two and three acres in extent and are essentially a comparison of tillage with winter cover crop; sod with heavy straw mulch; sod mulch,—grass raked up about the tree; and sod,—grass cut and let lie. Trees which had been permanently in sod alone, making the least growth, and with a tendency toward early maturity, sustained much less killing than cultivated or heavily mulched trees. It should be said that while the trees in sod with grass cut and let lie were small, they were making enough growth to be healthy. Trees weakened from any cause frequently suffered worse from winter injury.

The injury manifested itself as brown sunken areas much resembling blight cankers. These often involved one or more limbs and sometimes a greater part of the trunk, completely ruining the tree in many cases. A sparse foliage was common to winter-injured trees, either because of the killing of the bark, the sapwood, or both. Early in the summer a line of demarkation was apparent at the margin of the injured areas and although the bark was dead it frequently protected a sufficient amount of live cambium so that healing progressed beneath. This was particularly the case in old trees when the sapwood was not killed. Such superficial injury was common in the orchard of Mr. L. V. Doud, of Denver, Indiana, and healing has been excellent.

THE PEACH.

Injury to the wood of peach trees was very severe, the older trees being hurt the most. The bearing acreage of peaches in Indiana has probably been reduced sixty per cent from this cause. Injury was largely in the bark and sapwood of the trunks and main limbs on the southwest side of the trees. The periphery of the tree was generally in fair condition and even a few live buds existed in some cases. Some winter injured trees were as much as a week late in leafing out, but this apparently is not of itself to be construed unfavorably for such trees have often made good recovery.

Purdue Experiment Station undertook pruning and fertilizer experiments in the winter injured peach orchards. It was felt that this was a rare opportunity to ascertain the best treatments for winter injured trees. Naturally those trees were selected which had suffered material injury. It was impossible, however, to forecast from an examination of the trees early in the season whether or not they would survive. The consequence was that our most extensive plots furnished little or not any data for the reason that the trees were so severely injured to start with that they died regardless of the treatment. Likewise those plots that remain are

open to doubt, because while careful notes were taken on the condition of each tree at pruning time, such notes are not trustworthy as we have learned by experience. Trees for which no hopes were entertained proved to be alive and others in which the bark, cambium and sapwood looked to be in better condition, succumbed. Not knowing the initial condition of the tree it is impossible to say how much the recovery or dying as the case may be, was due to the treatment and how much to the previous state of the tree as determined by the winter.

Owing to the small number of trees the results, therefore, are not conclusive but simply interesting. Observations on the phenomena of winter injury in the field must necessarily be piecemeal because of the long intervals between the killing. When all the reports are published and correlated it may be that these data will fit in and serve to add to our total of knowledge on the subject. This is the only reason for presentation.

The pruning treatments involved checks, light, moderate and heavy pruning, and dehorning. The checks were left without any pruning whatever. Light pruning consisted in reducing the one-year wood about fifty per cent by topping and by cutting off at the first lateral. In moderate pruning the top of the tree was lowered still more by cutting off the taller branches to laterals lower down in the tree and by cutting back into two and three-year-old wood. It should be said that in all the pruning when larger branches were removed an attempt was made to leave those branches that seemed to be in the best condition. Heavy pruning was still more drastic, cutting back into secondary limbs and leaving the top of the tree five or six feet tall. Dehorning left only two to three feet of the main limbs.

The above treatments were given both *early* and *late*. The early pruning was done the second week in March when the trees were entirely dormant; the late pruning the second week in May. In the locality under consideration the shucks are ordinarily shed from the young peaches by May 1st. The late pruning was, therefore, given at the time the growers generally engage in such a practice.

Results in Orchard No. 1. This orchard was only in fair condition as it had not received consistent good care. In 1917 it had been cultivated and bore a very light crop. The trees were of the Elberta variety and planted in the spring of 1912. Table II gives the number of trees dead and partly dead under each treatment at the end of the 1918 growing season. Partly dead trees include those in which one limb or more failed to grow, but still having enough live wood to make a tree.

It is impossible to draw any fine distinction from the above data, but for the dormant pruning the moderate amount seems most successful. The greater number of live trees came through with no pruning at all. But that this was a mere plot variation is shown by the fact that in the late pruned check, which, of course, had no pruning the same as the early pruned check, there was one

TABLE II.

Effect of Pruning on Winter Injured Peach Trees in Orchard No. 1.

"EARLY"—PRUNED WHILE DORMANT				"LATE"—PRUNED IN LEAF		
Treatment	Total Number Trees	Number Trees Dead	Number Trees Partly Dead	Total Number Trees	Number Trees Dead	Number Trees Partly Dead
Check.....	10	0	0	13	1	2
Light.....	11	2	3	7	1	2
Moderate...	10	0	3	7	0	3
Heavy.....	10	2	4	7	0	3
Dehorned...	11	5	3	7	0	4

tree dead and two partly dead out of thirteen. The moderately pruned trees however really made a thriftier growth and a better recovery generally than the check or the light pruning. By September 1 the two later plots had shed many of their leaves with no sign of this under moderate pruning. The heavy pruning and dehorned plots were still holding their leaves at the first frost about November 1.

Comparing early and late pruning it will be seen that heavy cutting and dehorning were particularly disastrous when the trees were dormant, but when done in full leaf were quite successful. This was the outstanding feature of the experiment. The best commercial growers advance the theory, which is not without reason, that the top with its leaf surface seems to "pull" the sap up through the badly injured tissues and it would not generally rise otherwise. After the top has started the upward movement of sap, then it may be cut away and growth will continue. The facts are that in many mature peach orchards which have been severely winter-injured, dehorned trees have invariably died. Of course it is not possible for trees dehorned late to grow as big a top the same season as trees dehorned early, providing they survive. The indications are that if dehorning must be done the chances of success are materially improved if it is done after the trees are out in leaf. The moderate pruning was also successful when done late and had an additional advantage in that the operator could tell the condition of his trees at that time.

Interesting observations are still to be made on these trees as to how they will respond in fruitfulness and longevity. At present the moderate pruning seems to have encouraged sufficient vigor and at the same time makes possible a good crop the coming year. The trees in most cases are well set with plump fruit buds and it will be no small advantage to the grower to have a crop in 1919. Of course with the severely pruned trees a crop is not

possible, but it may be that having practically a new top they will be better able to stand under the strain of future crops and thus increase their productive life. Whether or not this would offset the chances for a crop in 1919 is a question. The extent to which these winter injured trees can recover is problematical. A crop next year will spell the ruin of some of them. It is reasonable to expect, however, that their general condition will tend to improve.

Results in Orchard No. 2. This orchard, in the same neighborhood as the previous one, had had excellent management and the trees were in a thrifty condition and had borne a light crop in 1917. Treatments were a duplication of early pruning as carried out in Orchard No. 1 except that a check without pruning was omitted. The trees were eight-year-old Elbertas. The results as shown in Table III tend to corroborate the harmful effects of severe early pruning experienced in Orchard No. 1.

TABLE III.

Effect of Pruning on Winter Injured Peach Trees in Orchard No. 2.

TREATMENT	EARLY-PRUNED WHILE DORMANT		
	Total Number Trees	Number Trees Dead	Number Trees Partly Dead
Light	8	2	1
Medium.....	10	3	3
Heavy.	6	3	2
Dehorned.....	10	9	0

The distinction between the light and moderate pruning treatments is not quite so clear.

The Fertilizer Experiments. These suffered the same misfortune as the pruning plots,—too few trees. The results early in the season were not particularly noticeable except possibly a slightly better foliage, but later in the season when the check trees began to drop their leaves the fertilized trees still had a healthy, functioning foliage and the growth particularly when the fertilizer was used in conjunction with moderate pruning, was as much as a foot more in some cases than on unfertilized trees. The fertilizer used was two pounds of nitrate of soda on a six-year-old tree applied broadcast beneath the spread of branches just before the leaf buds opened.

WINTER INJURY IN OHIO.

By W. PADDOCK, *Ohio State University, Columbus, Ohio.*

The winter of 1917-18 was the most severe that has been experienced in Ohio in many years. Even the oldest inhabitants

cannot remember anything like it.

The peach growers of the Port Clinton district suffered the greatest loss, as fully 90 per cent of the trees above six years of age were either killed or so badly injured that it would not pay to keep them.

One striking thing in connection with the injury at Port Clinton was the fact that quantities of fruit buds survived the winter, even on trees that failed to send forth a leaf in the spring. Some of these buds even set and matured fruit on twigs that were without a sign of a leaf all summer. This was a condition entirely new to the writer. It would appear then that under certain conditions the fruit buds of the peach are not nearly so susceptible to cold as had been supposed. What are these conditions?

While no exact experiments were carried out, the experience of practical growers again demonstrates that under Ohio conditions, moderate pruning of frozen peach trees gives better results than either severe or very light pruning, or than none at all.

The formation of frost cankers in the crotches of young apple trees is another form of winter injury not entirely unknown, but by no means common in this state. Fortunately this injury was not wide-spread, only a comparatively few orchards in the interior of the state being affected. In one orchard of 60 acres near Columbus, 500 seven-year-old trees were affected, 100 of them so severely that they were removed at once. Many of the others were so severely injured that their value was doubtful. Unfortunately the Stayman Winesap undoubtedly is more susceptible to this injury than are most of the other standard varieties.

Other incidents of the winter were the passing of a number of mature Baldwin trees and the killing to the ground of Catawba grape vines in some vineyards.

WINTER INJURY TO FRUITS IN WISCONSIN IN 1918.

By J. G. MOORE, *University of Wisconsin, Madison, Wis.*

Some winter injury occurs in Wisconsin every year. Usually it is confined to restricted areas, but occasionally is general. There was a very little more injury to the trees last winter than normally occurs. One of our common and more serious forms is that which has been frequently called "south-west injury." The characteristic appearance and general location of this type seems to correspond quite closely to that reported by Greene as occurring in unprecedented amounts in Indiana and New York last winter, with the exception that in Wisconsin the injured areas are confined largely to the south and southwest side of the trunk and the inner side of the foundation branches on the north and east sides of the tree. This type of injury did not occur in appreciably greater amounts last year than commonly.

Plums were more severely injured than usual; even some of the American varieties suffered. One instance of injury of a very different type was reported by Professor R. H. Roberts as oc-

curing in an orchard of Gano. In this orchard the entire tops of the trees were dead, following severe trunk injury, but the roots were uninjured. This orchard was located on rather low flat land.

No root killing, which is another serious form of winter injury in Wisconsin, was reported as occurring on bearing trees last year. Crown grafted cherries in which the crown was set above the surface of the soil, suffered somewhat in locations where there was no protection by snow.

Some nurserymen suffered heavy losses due to killing of stock even to three years of age. Both tops and roots were killed. This injury occurred to much greater extent than usual.

Probably the most serious injury during the winter of 1917-18 was blossom bud injury. It was particularly severe on cherry and occurred to some extent on apples. In the Sturgeon Bay section the Early Richmond crop was practically destroyed.

THE PRUNING OF WINTER-INJURED PEACH TREES.

By A. J. GUNDERSON, *University of Illinois, Champaign, Ill.*

INTRODUCTION.

Unusual and prolonged periods of low temperatures in southern Illinois during the winter of 1917 and 1918 resulted in severe injury to peach trees. Southern Illinois is rarely visited with a temperature of twenty-five degrees below zero and the effects of such low temperature and the resulting injury to peach trees caused considerable anxiety among peach growers. Many growers were at loss to know just how severely their trees should be pruned. Our advice was to prune moderately in the case of both old and young peach trees, exception being made to trees planted in the fall of 1917, in which case it was recommended that the usual cutting back to whips of June-budded or small yearling trees be practiced. The recommendation to prune moderately was based upon results published in New York State Experiment Station bulletin 269 which states that "the results from a moderate pruning were encouraging in the case of both young and old peach trees." It was felt that these same recommendations might properly be applied to conditions in southern Illinois, especially since the conditions in the peach growing sections of New York during the winter of 1903-4 were almost identical to those of Illinois during the winter of 1917-18.

EFFECTS OF WINTER-INJURY.

Winter-injury to peach trees in Illinois during the winter of 1917-18 included the killing of the fruit buds, which resulted in a complete failure of the crop, and injury to the wood of different ages, varying from a slight injury to the tissues to severe injury and subsequent death of the trees. One-year planted trees suffered less than older trees.

INTERNAL SYMPTOMS OF WINTER-INJURY.

The internal symptoms of winter-injury appeared in the form of discoloration of the inner wood, varying from light brown to dark brown, and the cambium layer turning a pale or watery green. The odor of the cell sap was very sour, suggesting fermentation. These conditions affected the trunk and branches, roots in most cases remaining normal in appearance due perhaps to the protective covering of snow.

EXTERNAL SYMPTOMS OF WINTER-INJURY.

The first external symptoms of winter-injury appeared in the form of shriveled bark which caused lenticles to stand out prominently, giving the bark a rough appearance; also in the form of cracking or splitting of the tree trunks. A later symptom was noted where leaf-buds expanded due to local supply of stored food but finally wilted and died due to the inability of injured cells to conduct sap from the roots. This appeared on single branches and on entire trees.

RELATIVE DEGREE OF WINTER-INJURY IN DIFFERENT
SECTIONS OF SOUTHERN ILLINOIS.

The degree of winter-injury to peach orchards in southern Illinois varied not so much with latitude because the low temperatures were quite uniform, but with differences in vigor and healthiness of the trees, elevation of the orchard, and the age of the trees. Trees devitalized as the result of previous injury from borers, gumosis, and lack of proper feeding and cultivation, were most severely injured and in many cases died. Those located on well elevated and properly drained soil showed less serious injury than those situated on level land or in "pockets." In some cases a difference of a few feet in elevation within the same orchard caused a marked difference in the severity of the injury. One-year planted trees appeared to be injured less than older trees. These factors and conditions and not so much the maturity of the wood seemed to be responsible for the serious winter-injury to peach trees in southern Illinois.

VARIETIES INJURED.

Little opportunity was afforded to study winter-injury on any variety other than Elberta and Hale. The former variety is the most important one grown commercially in southern Illinois while the latter has been planted to some extent. It has been thought by certain peach growers of the other states that Hale is more resistant to low temperatures in the bud than Elberta, but both varieties proved failures in this particular during the winter of 1917-18. Hale is a less thrifty grower than Elberta in southern Illinois, and showed as much and in certain cases more serious wood-injury.

EXPERIMENTAL PROJECTS.

Serious winter-injury to peach trees rarely occurs in southern Illinois and in order to take advantage of the opportunity offered to obtain information for future reference, investigations were begun to determine a satisfactory way of handling such trees.

VORIS ORCHARD, NEOGA, CUMBERLAND COUNTY.

The entire Voris peach orchard at Neoga showed serious winter-injury and several dead trees in the lowest parts. The trees were five-year-old Elbertas which had, up to date, received fairly good care. These stood on level, gray silt loam.

Four rows of trees containing seven trees per row were selected and pruned as follows, on March 28, when the leaf-buds were out:

Row 1.—One-half of last year's wood was removed.

Row 2.—Trees were "dehorned" back to within eighteen inches or two feet of the trunks. Three trees were waxed at the cut surfaces and four left unwaxed.

Row 3.—Check, unpruned.

Row 4.—Four trees in this row had all of last year's wood removed. Three trees were pruned leaving four inches of last year's wood.

Judging from the discoloration of the wood of all the trees in this experiment the injury appeared to be very severe. In the case of row 2 where the trees were "dehorned" to within eighteen inches to two feet of the trunk, it was thought that the waxing of the wounds immediately after pruning might check evaporation and aid recovery.

On July 23, observations were made upon the relative condition of the trees. Rows 1 and 4 from which one-half to all of last year's wood respectively had been removed, were the best from the standpoint of growth and amount and color of the foliage. The check or unpruned trees were making a straggling growth and presented an unthrifty condition.

The trees in row 3 which had been "dehorned" were in the worst condition, practically all the trees, both waxed and unwaxed being dead. The weather, however, during the summer was extremely hot and dry and no doubt, this condition was detrimental to the recovery of the trees.

On October 29, observations were again made to ascertain the condition of the trees in the different rows. Only one tree remained alive in row 3 which received the "dehorned" treatment. This had made the usual heavy growth characteristic of "dehorned" peach trees and carried practically no fruit-buds.

Rows 1 and 4 from which part to all of last year's wood had been removed had an abundance of fruit-buds present on strong wood. The unpruned trees in row 3 showed plenty of fruit-buds but these were borne on small, weak branches.

POFF ORCHARD, OLNEY, RICHLAND COUNTY.

The Poff peach orchard at Olney showed a variable degree of winter-injury. That part of the orchard well elevated and properly drained consisted of four-year-old Elbertas. The rest of the trees situated on more level and lower ground were three-year-old Elbertas which seemed to show slightly more serious injury than the four-year-old trees on higher ground. The soil of this orchard is yellow silt loam.

BLOCK 1.

Four rows containing five three-year-old Elberta trees were pruned in the following manner on March 26, when the leaf-buds were out:

Row 1. Pruned moderately. Last year's growth clipped.

Row 2. "Dehorned," the one and two-year-old wood removed.

Row 3. One-year-old wood removed.

Row 4. Check, unpruned.

On May 12, those trees from which the one-year-old wood was in part or entirely removed, rows 1 and 3 respectively, were making the best growth and carried the best colored foliage. The trees in row 2 which had been "dehorned" were growing slowly but had good foliage. Check or unpruned trees were making the poorest growth and carried sickly yellow leaves.

On July 9, the trees in row 3 from which all of last year's wood was removed had made the greatest amount of growth while the trees in row 1, whose one-year-old wood had been clipped was next, with the trees in row 2 which were "dehorned," and those of row 4 which remained unpruned, following in amount of growth. Trees which had been "dehorned" were reduced so low that much of the growth lay on the ground, and was, therefore, useless so far as its ability to carry fruit in the future was concerned. Then too, the size was greatly reduced and the growth was very dense and upright in character.

On October 30 when most of the leaves had fallen, observations were made to determine the relative amounts of fruit-bud formation on the trees of the different rows. The greatest number of fruit-buds developed on the trees in row 1, whose one-year-old wood had been clipped; the next greatest number on row 4 which was not pruned, and the smallest number of buds were present on row 3, from which the one-year-old wood had been removed. Row 2 which had been "dehorned" developed practically no fruit-buds due to the heavy primary growth that resulted from the severe pruning.

The fruit-buds on the trees of rows 1 and 3 were carried on strong growth, while those on the unpruned trees in row 4, developed on small, weak branches.

BLOCK 2.

Five rows of four-year-old Elbertas were pruned in the following manner on March 26, when the leaf-buds were out:

Row 1. Pruned moderately. Last year's growth clipped.

Row 2. "Dehorned," the one, two and three-year-old wood removed.

Row 3. One-year-old wood removed.

Row 4. "Dehorned," the one and two-year-old wood removed.

Row 5. Check, unpruned.

On April 1, one pound of nitrate of soda was applied broadcast to three trees in each row for the purpose of studying the effects of this material on the recovery of the trees from the effects of winter-injury.

On May 12, the trees in rows 1 and 3 from which one-year-old wood had been clipped or entirely removed, respectively, were making a better type of growth than those in rows 2 and 4 which had been "dehorned," removing one, two and three-year-old wood and one and two-year-old wood respectively. The unpruned trees in row 5 were making weaker growth at this time.

The foliage of the trees which had received nitrate of soda was heavier and of a darker green color than that of the untreated trees. This difference was more apparent in the check and moderately pruned trees than in the case of those "dehorned." On July 9, the rankest growth had been made by the trees in rows 2 and 4 whose one, two and three-year-old wood, and one and two-year-old wood respectively, had been removed. The tops were very dense and reduced so low that many of the branches lay on the ground. The effects of the nitrate of soda were still noticeable on the check trees and those moderately pruned.

The trees which were making the most desirable growth from the standpoint of amount and spreading habit were those in row 1, whose one-year-old wood had been clipped. The next best trees were those in row 3 whose one-year-old wood had been entirely removed. The unpruned trees were better in every respect than those "dehorned," both from the standpoint of size and shape.

Observations were made October 30 on the relative amount of fruit-bud formation on the trees in the different rows. The trees in row 1 whose one-year-old wood had been clipped, carried the largest number of well distributed, vigorous fruit-buds on desirable small-sized branches. The trees in row 3 whose one-year-old wood had been entirely removed had a good many poorly distributed fruit-buds carried on wood that was a little too heavy to be desirable. The tops were so dense as to require considerable thinning of the branches and consequent removal of many fruit-buds.

Very few fruit-buds were present on the "dehorned" trees in rows 2 and 4. This was due to the fact that the usual long and heavy primary growth of branches developed, on which few fruit-buds generally appear.

INTERNAL APPEARANCE OF WOOD TISSUES AT THE END OF
THE GROWING SEASON.

Examination of the internal tissue of the wood of both branches and trunks was made during November after the growing season had ended. It was observed that a new layer of sapwood had been formed of greater width in the case of tree trunks than branches. The heart-wood and pith had assumed a "punky" condition, suggesting decomposition. Whether such a condition will eventually prove detrimental to the productiveness and vigor of the trees remains to be seen. In all probability it will not because of the relatively short life of peach trees.

SUMMARY.

1. Unusually low temperatures of the winter of 1917-18 caused serious injury to peach trees in southern Illinois.

2. One-year planted trees showed less injury than older trees.

3. Winter-injury included killing of fruit-buds and injury to trunks and branches. Little root injury developed as the result of below zero temperature.

4. Discoloration of the inner wood varying from light to dark brown was the principal internal symptom of winter-injury.

5. Trees devitalized by borers, gumosis and starvation suffered serious winter-injury.

6. Trees located on the lower parts of an orchard showed more injury than those on the higher parts.

7. Elberta is the principal commercial variety grown in southern Illinois. Hale is grown to some extent and showed more serious wood injury than Elberta.

8. On three, four and five-year-old Elberta peach trees, moderate pruning in the form of the clipping back of last year's growth gave the best results from the standpoint of size, shape and openness of the trees and in the number of strong fruit-buds.

9. "Dehorning" winter-injured peach trees of these ages proved to be a poor practice and was entirely unnecessary. It reduced the size of the trees and in the case of five-year-old Elbertas in the Voris orchard, killed the trees.

10. Waxing the cut surface of "dehorned" trees was of no value.

11. Nitrate of soda at the rate of one pound per tree increased the amount and color of the foliage on moderately pruned four-year-old Elbertas, but was of little value on "dehorned" trees of this age and variety.

12. No pruning at all gave better results than the "dehorning" of three, four and five-year-old trees.

13. Discoloration of the inner wood of peach trees is not an absolute indication of the inability of trees to recover from the effects of winter-injury.

14. New sap-wood formed in most cases where pronounced discoloration had resulted.

15. Heartwood and pith of trunks and branches showed a "punky" or decomposed condition in November.

HARDINESS IN TOP-WORKED VARIETIES OF THE APPLE*

By M. J. DORSEY, *University of Minnesota, St. Paul, Minn.*

INTRODUCTION.

The question as to whether a tender variety is increased in hardiness by top-working on a hardy root or stock has been given considerable attention by growers in sections of the country where the winter temperatures are low. Some have contended that by this means the question of hardiness can for the most part be solved. This question was considered of sufficient importance from the breeding standpoint to investigate further in material which became available at the Fruit Breeding Farm. If a relatively tender variety can be carried through a severe winter on a hardy stock less attention need be paid to hardiness in new seedlings or in introductions.

A fairly definite winter temperature range may be expected to occur in Minnesota and while the "test winters" have been some distance apart, they have served as a rude reminder to those who have forgotten or ignored the previous experience. The winters of 1872-3, 1884-5 and 1896-7 were especially severe and are known in the Northwest as test winters. While the winter of 1916-17 was quite severe, there was less injury than in 1917-18 and it is doubtful whether the latter will rank with the other years from the standpoint of the extent of injury to fruit plantings.

Frosts as well as the temperatures below zero may do considerable damage to fruits. Consequently the greatest injury to fruits does not necessarily come in the northern countries where the extremely low temperatures are reached. Resistance to low temperature is as live a question in Florida and California as in Minnesota.

The temperature is approximately the same all about an exposed plant, but some parts may be hardy and others not. For instance, in the plum the fruit buds may kill while the wood does not, or as in *Amygdalus davidiana*, which is one of the hardiest of the peach tribe in Minnesota, the fruit buds kill during even a mild winter, and while the wood has been considerably browned there has been little killing back of the twigs. There appear to be certain tissues of the tree then, where the injury from the low temperatures is greater than in others. The tender tissues serve as the best index to hardiness and the severer or test winters emphasize the killing at the weakest points. In the apple

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the wood is severely injured before the buds are affected or the twigs show any killing back. This injury is clearly seen in the marked browning of the wood tissue, and can be detected in cases of slight injury before the vigor of the tree is perceptibly impaired. The degree of this browning varies with the severity of winter and with the hardiness of the variety and can be considered a most sensitive index of the winter injury.

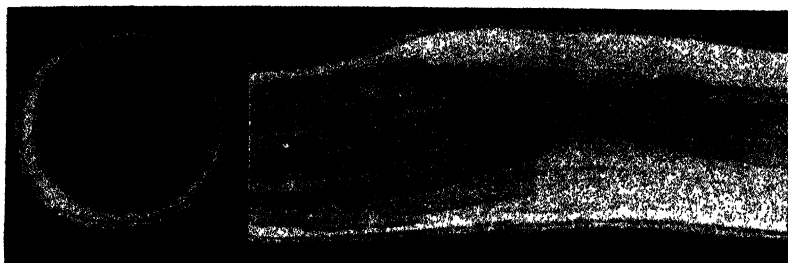


Plate I.—A photograph of a median section of a graft at the point of union. The scion (a) is Grimes and the stock (b) is Hibernial. Note the darker browning of the Grimes wood beginning at c which is the point of union. Compare the browning of the wood of both stock and scion with the new spring growth as at d. Above is shown a cross-section of Grimes.

Turning now to top-working it will be seen that the old question of stock and scion is again introduced. It is not the intention here to enter into a discussion of the influence of the stock upon the scion. This relation is of interest now primarily as it affects hardiness. In horticultural practice, bearing habit, maturity and dwarfing are well known influences of the stock upon the scion. The stock, no doubt, has its primary influence upon hardiness of the scion so far as it influences early maturity. It will be evident that if a hardy variety is grafted upon a tender stock, the graft will be left stranded when tree or root, as the case may be, is winter-killed. The question then, may be put in an extreme form—will an otherwise tender variety winter-kill on a hardy stock.

WINTER INJURY DURING 1916-17.

The winter of 1916-17 was not particularly severe. The temperature records are not available for the Fruit Breeding Farm, but at Minneapolis, twenty miles farther east, the minimum temperature registered at the United States Weather Bureau was -25°F. , January 15 and February 2, while a temperature of -24°F. was reached December 21, and -15°F. on March 4.

The injury to apples was quite severe in some sections of Minnesota and at the Fruit Breeding Farm was sufficiently severe to draw a relatively sharp line between the extremes in hardiness. The varieties included in Table I were growing under clean cultivation and generally were not protected from the wind. The

growth conditions favored late maturity so that as far as this factor enters the killing may have been emphasized.

The degree of injury was determined by cutting into selected limbs about one to one and one-half inches in diameter, three to five annular rings deep with a sharp knife or hatchet. The degree of browning was divided into four classes as indicated in the heading of Table I. There was as a rule less browning in the bark than in the wood and for this reason the wood browning was taken as the basis for classification. The degree of browning is greatest on the trunk and large branches and varies but little on the branches from one to four years old. However, care was taken to classify the different varieties as to the degree of injury, as far as possible, by selecting limbs of similar size.

TABLE I.

The degree of wood browning of sixty standard apple varieties in 1916-17. Instead of indicating the degree of injury of each variety in the table by a star or dash, the stock or root upon which it is growing is written in. P. baccata and Paradise were used as root grafts only. Patten Greening and Hibernial were used as trunks and where these stocks appear in the table it means that the variety in question was either budded or grafted on them. In the case of those varieties listed as being on P. baccata or Paradise roots, the trunk was composed of a number of varieties and is not given.

Variety	Range in Degree of Winter Injury to the Wood			
	No Injury	Slight Brown	Brown	Dark Brown
Aitkin	Paradise	P. Greening	P. baccata	Paradise
Alexander		Hibernial		
Anisim		P. baccata		
Arctic				
Banana	Paradise			
Belleflower		Paradise		
Ben Davis		Paradise		
Black Den Davis		Paradise		
Black Pearmain				
Brilliant			Paradise	
Borovinka		P. baccata		
Brier Sweet	P. baccata		Paradise	
Champion	P. baccata			
Delicious			Paradise	
Delicious			P. Greening	
Delicious			Hibernial	
Evelyn		P. baccata		
Evelyn		Paradise		
Fameuse		Paradise		
Fameuse		P. Greening		
Fameuse		Hibernial		
Florence				P. baccata
Gano				Paradise
Gano				Hibernial
Grimes Golden	Paradise			

TABLE I—Continued.

Variety	Range in Degree of Winter Injury to the Wood			
	No Injury	Slight Brown	Brown	Dark Brown
Grundy				Paradise
Grundy				Hibernal
Haas	Paradise			
Hibernal		<i>P. baccata</i>		
Hubbardston				Paradise
Hubbardston				<i>P. Greening</i>
Iowa Beauty.....	Paradise	<i>P. baccata</i>		
Jewetts Red.....	Paradise	<i>P. Greening</i>		
Jonathan				Paradise
King David.....		Paradise		Hibernal
Lowland Raspberry...	Paradise		<i>P. baccata</i>	
McIntosh		<i>P. Greening</i>	Paradise	Hibernal
Maiden Blush.....		Paradise		
Maiden Blush.....		<i>P. Greening</i>		
Malinda		Paradise		
Martha	<i>P. baccata</i>			
Milwaukee		<i>P. Greening</i>		
Milwaukee		Hibernal	Paradise	
Minkler.....			Paradise	
Okabena		<i>P. baccata</i>		
Oldenburg		<i>P. baccata</i>		
Patten Greening.....		<i>P. baccata</i>		
<i>Pyrus baccata</i>	<i>P. baccata</i>			
Red Astrachan.....		<i>P. baccata</i>		
Red Astrachan.....		Paradise		
Ridpath Sweet.....	<i>P. baccata</i>			
Repka Malenka.....		<i>P. baccata</i>		
Rome Beauty.....		Paradise		<i>P. Greening</i>
Roxbury Russet.....			<i>P. baccata</i>	
Salome				
Scott Winter.....	Paradise			
Spitzenburg	Hibernal	Paradise	Paradise	
Stayman Winesap.....				
Superb		<i>P. Greening</i>		
Sweet Russet.....	<i>P. baccata</i>		<i>P. baccata</i>	
Summer Champion....			Paradise	
Tompkins King.....		<i>P. baccata</i>		
University		Paradise		
University		<i>P. baccata</i>	Hibernal	
Wagener		<i>P. baccata</i>	Paradise	
Wagener			Paradise	<i>P. baccata</i>
Wealthy			Hibernal	
Winesap	Paradise			
Windsor Chief.....	Paradise	<i>P. Greening</i>		Paradise
Wismer Dessert.....				
Wolf River.....		Paradise		
Wolf River.....		<i>P. baccata</i>		

Golden Russet	1	1	1	2	1	2	1	2	3	15	2	1	2	4	2	1	3	2	2	19
Grimes	1	1	1	2	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	4
Grundy	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	4
Hubbardston	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	4
Hubbardston-Nonsuch	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	4
Iowa Beauty	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	4
Jewells Sweet	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	4
Jewells Winter ^(s)	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	4
Jewells Red	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	4
Jonathan	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	4
King David	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	4
Lowland Raspberry	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	4
Lowry	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	4
Lynan Prolific	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	4
McIntosh	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	4
McMahon	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	4
Maiden Blush	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	4
Malinda	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	4
Mann	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	4
Martha	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	4
Milwaukee	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	4
Minkler	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	4
New Western Greening	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	4
Olden Greening	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	4
Patten Greening	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	4
Peerless	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	4
Pyrus boconia	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	4
Red Astrachan	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	4
Red Canada	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	4
Red Wing	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	4
Repka Malenka	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	4
Rome Beauty	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	4
Roxbury Russet	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	4
Salome	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	4
Spitzenberg	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	4
Stayman	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	4
Sugar Loaf	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	4
Summer Champion	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	4
Superb	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	4
University	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	4
Wagener	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	4
Walbridge	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	4
Waltham	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	4
Waltham Chief	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	4
Windsor	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	4
Winesap	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	4
Winesap Banana	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	4
Winesap Dessert	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	4
Wolf River	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	4

(1) Data taken on limbs one to one and one-half inches in diameter.

(2) Data taken on trunks eighteen inches to two feet above the ground.

(3) Possibly some trees are not true to name.

In Table I the first column, headed "No injury," contains the hardy varieties. In only five instances are varieties classified in both the first and second headings and in no case has a variety been hardy on one stock and classified under dark brown on another. Oldenburg, Wealthy, and Patten Greening, which are grown so widely in Minnesota, were all slightly injured, and even Hibernial, which is recommended so generally as a stock, was injured slightly. *P. baccata* did not brown. Such varieties as Tompkins King, Hubbardston, Jonathan and Delicious, judging from these results, are not sufficiently hardy to be of value in Minnesota except in only the most protected localities.

It is also of interest to note that relatively hardy stock has not prevented the tenderer varieties, such as Delicious or Hubbardston, from being injured. The degree of injury on two different stocks is in no case widely different, that is, no examples have been found where a variety is uninjured on one stock and dark brown on another. In nine varieties both stocks are written in the table under the same degree of injury, in nine under different but adjacent degrees of injury, while in four a single class or degree intervenes. In the varieties grafted on three stocks the same degree of injury occurred on all in two cases, while in the third each stock is written in under a different degree of injury. Summarizing Table I, it will be seen that, with one exception, all degrees of injury occur on each of the stocks. Considering the difficulty of consistently classifying winter injury as to degree by the density of the browning these results are fairly consistent.

In view of the fact that the observations as to degree of injury in the varieties listed in Table I were made on a small number of trees in most cases, the question enters as to the difference in the degree of injury to the same variety on the same stock. This point is covered in Hibernial, which has been classified with respect to the variation in the degree of winter injury when grown on *P. baccata* roots. Out of thirty-eight different trees there was no browning in four, slight browning in twenty-two, eleven were medium brown and one dark brown. As to injury, Hibernial is listed in Table I as slightly brown. While the evidence on this point for the other varieties in Table I is not so extensive, it points in the same direction.

WINTER INJURY IN 1917-18.

There was much greater injury to apples in 1917-18 in Minnesota than for a number of years preceding. The fall was dry, there was less snow than usual and the temperatures were low. This combination of conditions is always dangerous to fruits in this latitude.

In comparison to 1916-17, the lower temperatures this year at Minneapolis were as follows: December 28 and 29, -22° F.; January 31, -25° F.; February 1, -25° F., and as late as March 10, 0° F. The chief difference between the two years was the drier fall and lighter snowfall in 1917-18.

The data on the variety list presented in Table II, pages 42 and 43, are not presented in the same form as in Table I, but they show essentially the same thing, the degree of injury to top-worked varieties. Instead of the stock being written in the table, under the degree of browning, the number of trees upon which observations were made is entered. A larger number of varieties is also included.

From the evidence presented in Table II it will be seen that a number of the standard varieties of the Eastern States approach the limit of their range in Minnesota. From these data it appears that some varieties are not as hardy in this state as has been supposed. For instance, Northwestern Greening, which has been planted widely, was severely injured in the trunk last year (Table II) but only slightly injured in the top.

The evidence presented in these two tables may be briefly summarized in three statements: (1) when the influence of the winter is measured by the degree of browning of the wood it will be seen that generally the injury is more severe than is popularly supposed, more severe in fact than is indicated by the killing back of the twigs; (2) the smaller branches and limbs of the top show less browning than the trunk; and (3) the hardiness of the scion is independent of that of the stock and if a hardy stock does have an influence upon the hardiness of the scion, it is not sufficient to prevent it from being injured by low temperatures.

While a browning of the wood can be considered as a fairly accurate index to the hardiness of a variety, it does not, except where it occurs to a severe degree necessarily result in permanent injury. New wood is simply laid down around the brown area and a cross section of the limb shows a succession of darkened circles corresponding to the years of severe injury.

FRIDAY, DECEMBER 27, 1:30 P. M.

EXTENSION WORK IN HORTICULTURE.

By W. R. BEATTIE, *United States Department of Agriculture, Washington, D. C.*

The extension work in horticulture as conducted by the Bureau of Plant Industry, United States Department of Agriculture, in co-operation with the States Relations Service of the Department, includes all those crops commonly referred to as vegetable or "truck crops," grown in the home garden and for market. Owing to the fact that the connection between the Department and the Extension Divisions of the various states in this line of work has not been fully made, there remains considerable organization work to be done. In certain of the states where the trucking interests are of great importance projects are already formulated and the work well under way. This is especially true in the states where there is an extensive production of crops like Irish potatoes, sweet po-

tatoes, early tomatoes, asparagus, cabbage and onions. Owing to the urgent necessity for stimulating food production the horticultural forces of the various extension divisions have been compelled to devote most of their time to the emergency movement. Now that conditions are becoming normal greater attention can be devoted to the important extension projects. The Federal Department is limited both as to funds and workers and cannot hope to lend very much active assistance to the work in the various states, but it is the plan that the Department's specialists should work in close co-operation with the state leaders with a view to systematizing and correlating the extension work in horticulture. A certain amount of what might be called survey work must necessarily be done before the needs of any particular industry can be fully met. A good example is found at present in that of the tomato canning industry and its relation to the production of tomatoes for canning purposes. Another example is found in the matter of proper field methods in growing both Irish and sweet potatoes for storage and for the market. In a few cases the problems are local and apply to one or two states only, but for the most part these problems are of a general nature and apply to a large section of the country.

CITY HOME VEGETABLE GARDENS.

During the past year the home vegetable garden has been encouraged as one means of increasing our food supply. Owing to the shortage of man power the desirability of enlisting the spare time of persons who were engaged in manufacturing and mercantile lines was realized. It was also found that a large area of suitable gardening land was available within the corporate limits of many of our cities. By mobilizing the idle land and the spare time of city people it was possible to produce from \$300,000,000.00 to \$400,000,000.00 worth of food without interfering with the regular production channels. These city backyard and vacant lot gardens have not only proven a success as an emergency measure but their value as a part of our economic system has been fully demonstrated. The results of the city garden movement may be summed up as follows:

First.—The backyard and vacant lot vegetable gardens, planted and tended by city people, have yielded a substantial addition to our food supply.

Second.—The products of city gardens are the result of the enlistment of idle land and spare time that would not otherwise be utilized.

Third.—All transportation is eliminated.

Fourth.—All selling and delivery costs are saved.

Fifth.—The products come to the table fresh.

Sixth.—By having plenty of fresh vegetables the people eat less bread, meat and fats, and enjoy better health.

Seventh.—The city garden has provided vocational training and outdoor exercise for thousands of people who reside in apartments and close city quarters.

The production of vegetables in city backyards and on vacant lots is not a fad, but a substantial economic movement the effects of which have proven more far-reaching than the promoters of the movement ever dreamed. As a result of the city garden development thousands of people have become permanent producers and their efforts constitute a substantial addition to the creative forces of this country. The work of organizing the cities for the garden movement is yet far from complete. A survey of a number of cities reveals the fact that in no case has more than one-half of the available and suitable land been utilized. Of the land now in cultivation fully one-half is being planted to crops that cannot be profitably grown on a limited space. The people who cultivate the gardens have yet much to learn, but with all the results have been marvelous indeed. The city home vegetable garden has come to stay and the demand for land is now greater than at any corresponding time in past years.

Two distinct types of organization for home gardening have been promulgated. First, that of the city where a central board or committee is appointed. Funds are provided either by appropriation from the city revenues or by voluntary contribution, sometimes both. A garden leader or supervisor is employed and the entire city is organized into groups or districts. Publicity is obtained through the local press and the cooperation of all business men is sought.

The other type of organization is that of the commercial concern or manufacturing plant where the employees are organized for gardening. Where sufficient land is not available in connection with or adjacent to the homes of the employees, a central tract is secured, ploughed, fertilized and apportioned to the employees who would not otherwise be able to secure land.

A good example of the city organization is that of Indianapolis, Indiana, where the number of war gardens the past year was 55,191 and the estimated value of the products of these gardens was \$1,437,165.00. Already more land has been allotted by the garden committee of Indianapolis for use in 1919 than was planted during 1918. One-half of these allotments are to new people, proving conclusively that the interest in gardening in cities is rapidly increasing. Philadelphia, Pennsylvania, has had its Vacant Lots Gardening Association for the past 22 years and this city needed no campaign to stimulate food production when the war came upon us. The work in Philadelphia is organized under the Vacant Lots Gardening Association and a paid supervisor with the necessary assistants and office help is maintained throughout the year.

A good example of an organization on the part of manufacturing interests is found in that of the Firestone Tire Company of Akron, Ohio. During the past season 311 centrally located gardens were

planted by the employees of the Firestone Company. A time clock was installed, also a system of keeping accurate record of the products grown in the gardens. The total value of the products was \$6,403.00. The expenses incurred for supervision were \$1,472.00. The average return from each garden was \$20.59. The average net compensation per hour for the time spent in the garden by the employees was 84 cents.

No accurate figures are obtainable as to the number of emergency home vegetable gardens planted in the United States during 1918, nor as to the value of the products. It is safe to assume that the actual number of gardens was higher than the majority of estimates. A pretty careful survey of the work in Indiana indicates that the number of war gardens the past year was over 640,000, mostly within the limits of cities and towns. The estimated value of the products from these gardens was \$15,000,000.00. In Minneapolis, Minnesota, the garden committee estimated that there were 10,000 gardens within the city limits. An actual check or count made by the mail carriers of the city disclosed the fact that there were 35,181 gardens in the city, or more than three times as many as were estimated. In Marion, Indiana, a city of 27,500 population, an actual survey revealed the fact that there were 13,041 home and vacant lot gardens, or a little more than one garden for every two persons in the city. The State of Ohio reports 102,875 gardens with the products valued at \$1,922,475.00. In the City of Columbus alone there were 32,207 gardens planted. Out of this number 6,438 were vacant lot gardens, and of this number of vacant lot gardens only 83 were neglected and not carried through the season.

This work of food production on city land by city people has not been without its difficulties. In many instances the real estate owners have declined to allow their land to be used for garden purposes on account of possible injury or prevention of its sale. The spirit of vandalism has manifested itself in a few instances, but on the other hand the movement has been so popularized through the press that the element of the population who under ordinary conditions would oppose a movement of this sort have feared to molest the gardens. The value of complete organization and leadership has been fully demonstrated and the results in the various states have been in direct proportion to the organization and leadership. The work has been participated in by the extension forces of the state colleges, by the local councils of defense, the business men's organizations and in many instances by the educational forces of the states. The work has resulted in a broadening of the view-point of city people and a realization of the possibility of feeding themselves from their own back yards. If no other result than this were obtained, the small amount of money that has been expended in the promotion of this enterprise has been well spent and has already returned 500 per cent on the investment.

With the return of horticultural extension activities to normal conditions it is the plan to so direct the work that the various state forces will be working along parallel lines and in a more coordinate manner than in the past. Extension problems that formerly were local in their scope have now become of a sectional and often of a national character. The production of certain classes of food has been extended both as to time of delivery on the markets and sources of production and there is need for a closer working relation between the interests of the North and South and East and West.

EXTENSION SERVICE IN POMOLOGY IN THE UNITED STATES DEPARTMENT OF AGRICULTURE.

By C. P. CLOSE, *United States Department of Agriculture, Washington, D. C.*

During the past two years the unusual agricultural conditions incident to the war have affected demonstration work in pomology seriously, particularly through the loss of state specialists, and incidentally by heading some of those left into the stimulation of gardening or special truck crop work. It may take many months to fill the state positions now vacant, but we trust this will be done as rapidly as possible. At present, 21 of the 33 northern and western states and 11 of the 15 southern states, are cooperating with the Federal States Relations Service in demonstration work in horticulture and pomology. The amount of funds, both federal and state, allotted for this purpose for the fiscal year ending June 30, 1919, is \$179,000.00. Some of the states may not be able to secure specialists and thus may not succeed in using their full allotments.

It is the duty and the pleasure of the Federal Specialist to become acquainted with the state specialists and to study their problems. In his travels from state to state he is able to get a broad view of the various problems upon which the state specialists are working and to gather in the best of both methods and subject matter. The occasional visits to the states are most helpful to the Federal Specialist and he hopes the state specialists are benefited also. It may be of interest to discuss briefly some of the different phases of the work.

EXTENSION SCHOOLS.

The extension schools furnished splendid opportunity for distributing extension knowledge. The specialist should fit his subject to the community needs and be quick to "size up" his audience as to just what and how much it will stand. He should have his subject matter well in hand and present it in plain and simple language, hold the interest of the audience, stop when he gets through or before if the audience becomes uneasy. His charts should be short and clear cut and contain one main idea with very few if any subdivisions, rather than a jumble of a dozen ideas, and

lantern slides should likewise show the special point under discussion. The aim should be to hold the audience to the lesson being taught and prevent anything else distracting their attention. Whenever possible the real materials themselves should be shown and used as, for instance, pruning tools, grafting and budding material, spraying mixtures, spraying equipment, etc.

FIELD DEMONSTRATIONS.

Field demonstrations require tact and judgment on the part of the specialist and the size of the group present may largely determine how the demonstration is to be conducted. In a pruning or other demonstration, if the group is too large to be handled satisfactorily, it may be practicable to divide it into sections and thus give more personal attention to a larger number of individuals.

The specialist must inspire confidence by his ability to prune or spray by doing it right and should explain each point as the operation proceeds. Working and talking go hand in hand here. He must not let his enthusiasm get the better of his judgment if something unforeseen and unpreventable interferes with his program. A case in point is that of an energetic young specialist who waded through 3 feet of snow to give a pruning demonstration in an orchard half a mile distant from the extension school. Only one or two of his audience stuck to him to the bitter end, and the time might have been better employed with the whole audience at the school.

CONTINUITY AND LOCATION OF DEMONSTRATIONS.

We feel that the best results follow the practice of having the demonstrations from 3 to 5 years in the same place with regular follow-up work during the entire year rather than to have single scattering demonstrations with little or not any follow-up effort. A demonstration plot thus becomes a nucleus from which good practices and methods will radiate. A demonstration should be continued long enough in a neighborhood to make itself felt whether this takes one year or ten. It would be well to get down to business on a time basis and drop the single, soon forgotten attempts, which pass for extension work. Then, too, the demonstrations should be located where they can and will arouse interest and are easily accessible to every one interested. If an orchard demonstration is located in a section devoted to truck or grain, or stock, and there is no hope of inducing the community to care for fruit trees which happen to be there, then it had better be discontinued. In such a section small fruit work should be tried as it will no doubt become popular when the case of growing small fruits has been demonstrated. A demonstration must meet the community's needs.

APPROVED LINES OF WORK.

In planning for work we should consult the wishes of a community and give practically what the community wants. If the desire is for the most commonplace things then demonstrate them. If the desire is for the highest grade of work then do that. If we believe some line of work is vital to a community we should endeavor to create a desire for that particular piece of work and then do it when requested to do so.

Some of the approved lines of work are as follows:

Pruning all kinds of fruit trees.

Spraying (liquid) all kinds of fruit trees.

Spraying (dust) for brown rot of peaches and general diseases and insects on apples.

Cultivation of orchards of all kinds.

Cover crops in orchards.

Renovating neglecting orchards.

Tile draining in orchards.

Fertilizing apple and peach orchards with nitrate of soda or sulphate of ammonia for quick effects.

Topworking fruit trees by grafting or budding.

Thinning fruit.

Grading and packing fruit, and marketing when this is a part of the project.

Develop local markets by local advertising and store window exhibits of the fruit.

Best varieties of fruits for different sections and climatic conditions.

Starting young orchards.

Exhibits at state and county fairs and fruit shows.

(Conservation of fruit by-products (fruit butters, jams, jellies, preserves, fruit juices, cider, vinegar, etc.)

Fruit grading and packing schools.

General lecture work at public meetings, farmers' clubs, horticultural societies and schools.

Landscape work on home grounds, school grounds, parks and other public grounds.

LINES OF NEW WORK.

There are a few lines of new work as follows which might be pushed vigorously:

Bush fruits (raspberries, blackberries, and currants and gooseberries out of the white pine belt), and strawberries for the farm and village home. These fruits can be grown with a minimum amount of care at rush periods of farm work and farmers can and will care for them when they cannot or will not spray fruit trees.

Community spraying. In many sections farmers cannot afford to maintain proper spraying equipment for, nor give the necessary time to, spraying a few fruit trees. The county farm bureau with the aid of the county agent and the state specialist if necessary,

should arrange with a competent man in each community to spray the farm and village home orchards at a remunerative price to be fixed for each locality. This arrangement will be the salvation of the home orchards in three-fourths of our territory. Everywhere the wail goes up that home orchards are going out and new ones are not being planted.

Community packing and shipping of apples under the following conditions: In sections where a few good varieties are grown in farm orchards to the amount of a carload or more of one variety in the whole community, and these are largely wasted or sacrificed on the local markets, the growers should be organized to the extent that they will pick, grade, pack and load a car of one variety to ship to a good market.

Sweet cherry production. The sweet cherry is not holding its own over much of the country largely, I believe, because nursery-men bud it on Mahaleb, instead of on Mazzard roots, thus making it short-lived. The trunks also sun-scald in winter, but this can be prevented by shading on the southwest side. By using trees on Mazzard roots and shading the trunks in winter the sweet cherry industry could be revived.

Nut trees where climate permits (Persian walnut, black walnut, butternut, hickory nut, pecan) as ornamentals for home lawns and farm shade trees as well as for parks, and hazlenut bushes for the garden and lawn. The nut trees are as beautiful and serviceable for ornamentals and shade as any other trees and are valuable for the nuts they produce.

Native trees and shrubs for use in landscape work around farm and village homes and in parks.

Black walnut growing (in cooperation with the department of forestry if such department exists at the state college or university). There are hundreds of thousands of acres of rough or unused land in the natural range of the black walnut which ought to be planted for both the timber and the nut crop.

Boys' and girls' club work with fruits, particularly the bush fruits (except currants and gooseberries in the white pine belt) and strawberries. This is one of the most promising lines of fruit extension work.

CONCLUSION.

General farm and labor conditions will be unsettled for a year or two, specialists will be scarce, and some discouraging features will be in evidence, but we should do our best with the means at hand and plan the demonstrations to cover a series of years and become centers of zones of influence from which will radiate the best in methods and practices that we are capable of producing.

EXTENSION WORK IN POMOLOGY IN NEW YORK.

By R. W. REES, *Cornell University, Ithaca, N. Y.*

While fruit is grown in all the counties of New York, the real commercial industry is confined to definite areas bordering Lake Ontario and Lake Champlain, and to the Hudson Valley. There are of course smaller areas along the finger lakes where some farmers make the greater portion of their income from fruit. In the fruit growing sections fruit is the principal source of income and the feature of the farm which receives first consideration. Outside the specialized fruit sections there are a few men who make a specialty of fruit, but for the most part it is grown as a side line on the general farm and is not a source of major income. In such sections when fruit prices are low the trees are left largely to the mercies of nature; when prices are high in comparison to farm products the trees receive what is locally known as "good care."

Our extension work in pomology may, therefore, be divided into two fields. First, that with communities in which fruit growing is a specialty, and second, communities in which it is of minor importance to the general farming. As a very large percentage of the commercial crop is produced by the former class of growers we feel our extension should be primarily with them.

In such sections there is very little call for demonstrations which merely show generally accepted orchard practices. Their primary interest is in specific local problems and in the fundamental principles underlying more general practices. Work in soil management must treat on the response of the tree rather than how to plow; in pruning the results are of more interest than the *latest improved method* of cutting off a branch; in packing, methods of organizing and operating central packing houses rather than how to face and tail a barrel of apples.

In some cases we have been able to be of assistance, in many we have not been able to give the desired information. I want to register a protest against the type of extension work which is limited to demonstrating so-called "known facts" and to lectures made up of statements purporting to be iron-clad rules for growing fruit. I feel that if our work is to be of benefit to the leading growers it must in most cases be in the form of helping them determine what really are their greatest problems, followed by work on their solution. For instance, in Western New York the matter of orchard cover crops seems to be an important one, but is one on which we have very little definite information. We hope by running a number of carefully planned, long-term field tests, or demonstrations if the term is more acceptable, to secure some information which will at least point in the right direction. The members of the Pomology Department at Cornell are united in feeling that there are several lines of work which can best be handled through long-term field tests where records are carefully kept. We also

feel that this type of work is within the proper province of extension activities and of benefit both to fruit growers and the extension man under whose direction it is conducted.

In New York all the leading fruit counties have county agents who are primarily interested in fruit and who have had good training for their work. All extension activities are in cooperation with them and all local arrangements made through them. In these counties during the past year three lines of work have received our greatest attention:

1. *Pruning Demonstrations.* These have very largely been of a specialized type, that is, have been given in orchards where some special problem is involved. In some instances they are held in orchards which were too closely planted and the problem is whether to cut out part of the trees or whether to retain all and shorten in the branches; in other cases pruning top-worked trees; handling of severely winter injured blocks, or other special pruning problems. Such demonstrations are advertised as specials, and the county agent endeavors to notify all men who have these special conditions to meet. This type of work assures a good discussion by those present and has, as a rule, been followed by satisfactory results.

2. *Demonstration Schools.* During the winter months the five-day demonstration school seems to be one of the most effective lines of extension work. In our fruit demonstration schools the departments of plant pathology, entomology, and pomology, are represented. Having ten periods of one and one-half hours each it is possible to take up the fundamental principles of plant growth and their relation to orchard practices in a way which is not possible in the single lecture or in the one or two-day institute. These schools also give an opportunity for personal acquaintance with the growers and time to talk over personal problems. I am thoroughly convinced this type of work is of more value in New York than the same amount of time spent in single lectures although not more than one-tenth as many people may be reached.

3. *Central Packing Houses.* Last spring at the suggestion of the county agent in Niagara County, one of our leading fruit counties, a conference was called to discuss the leading fruit questions, and to decide on the one which should receive concentrated attention for the year. Two or three growers were invited from each community and after discussing a number of questions they decided marketing to be their weak point, but back of this lack of uniformity in grading and packing to be the real factor. At a second conference of the same men a plan was worked out for a county campaign to explain the central packing house as the most efficient and rapid means of standardizing their grades and packs. The campaign was conducted by holding meetings in fourteen communities and explaining the county packing house plan to local growers. In each community the meetings were followed up by a local committee which made a survey of the number of men inter-

ested, the probable amount of their crops, the available buildings or sites for erecting buildings and the estimated cost. Following the survey, meetings were held to act on the committee reports. As a result at seven shipping points central packing associations were incorporated and operated during the past season. These seven associations are united in a central county association which makes the grade rules and will later look after such matters as advertising, transportation, distribution, securing barrels and packing accessories.

According to leading buyers the pack from the association was far more uniform and of much better quality than that from the same area in previous years. The members are not only satisfied but are enthusiastic about the success of the first year's operation.

In handling this type of work the extension representative will usually need to attend many of the meetings and conferences to supply information relative to organization, type of suitable buildings, floor plans, equipment, and matters of operation. The county agent is the man who is in position to know details of the local situation, to know the real leaders and to engineer their appointment on committees. The success of the work in Niagara County was due to the fact that the leading growers were back of the proposition, and that Mr. Peet, the county agent, followed it up very closely and straightened out many little difficulties which are sure to arise.

In the other fruit counties the time does not seem to be ripe for launching county-wide campaigns for central packing houses. In each county there are from one to three communities in which organizations will probably be formed and packing houses put in operation in time to care for next season's crop. It is always easy to interest a number of the poorer growers in such a venture, but it is poor policy to start an organization which does not have the support of the best men. The strength of an organization is limited to the strength of its leader.

THE NON-FRUIT SECTIONS.

As suggested earlier in this paper, outside the specialized fruit sections there are many general farms on which orchards have been planted. In many communities these orchards are fairly well cared for, but in very many a large percentage of the orchards may be classified as neglected.

I wish to raise the question as to whether there is any method of doing effective extension work in neighborhoods where the majority of orchards is in a neglected condition. As a general proposition, is it advisable to encourage increased plantings, or increased expenditure on the care of orchards in such sections? It has been my observation that the farmer who will respond to extension work knows what phases of his farm pay, and concentrates on these phases. If his orchard is neglected it is because it does not pay.

A few weeks ago I saw two orchards in a good farming section where pruning demonstrations were given last year. The demonstrations were well attended, but the brush still lay under the trees which were pruned at the demonstration, and not another tree had been pruned in either orchard. So far as I could learn not a single tree had been pruned in the neighborhood as a result of the demonstration.

Anyone can point to many special cases where neglected orchards have been put on a paying basis. I never have been able to find a way through extension work to arouse community interest and action sufficient to place any appreciable percentage of neglected orchards on such a basis. It seems a waste of time to do much work in such localities when there is more than can be attended to with men who are really interested in fruit and who are in position to make it pay.

HORTICULTURAL EXTENSION WORK IN INDIANA.

C. L. BURKHOLDER, *Purdue University, Lafayette, Ind.*

The work of the Horticultural Extension Division for the past two years has been on somewhat of a war basis. A good many lines of work have been followed with the idea rather of encouraging quantity rather than quality production, for the time being. It is the idea of this paper to present briefly the lines of work followed, organization and methods of circulating the demonstration results in the different localities.

POMOLOGY.

The major line of work in the past has been along pomological lines although the truck and vegetable gardening interests amount to several times that of pomology. The recent addition of another vegetable gardening man to the division will insure more attention to this part of the work. Previous to 1917 most of the orchard activity was devoted to the isolated meeting type of work. A hundred or more pruning and spraying demonstration meetings were conducted each spring which typifies this type of work. In the summer of 1916 a survey was made of 12 localities where meetings had been held in the past few years. Briefly the results of this survey were that a spring pruning and spraying meeting, for instance in a locality which was not followed up throughout the remainder of the season, did not give the most satisfactory results and in fact in a few cases did more harm than good.

Accordingly it was decided to put what demonstration work was to be done on a more permanent basis. Fourteen orchards were selected in which the demonstration work was to be carried on for a period of three years. Only counties were selected for this work which had considerable fruit interest and in which the county agent was sufficiently interested to really take the main

responsibility of the work and aid in giving the work publicity. The owner agreed to furnish all equipment and materials and do all the work under the direction of a representative of the Horticultural Department. The Horticultural Department promised to have a representative on hand to direct each important orchard operation. Most of these orchards became a center for the distribution of horticultural information from the very beginning. Two owners failed to live up to their agreements and were dropped. The work was very discouraging during the first summer in several of the orchards. No interest was shown throughout the entire summer until the crop of apples began to ripen in the fall, after which interest increased rapidly.

G. E. Metzger, County Agent in Elkhart County, has made fine use of the demonstration orchard idea. He is now keeping records on seven orchards in different localities in his county. In 1917 he had a mailing list of fifty men who were taking some care of their orchards and putting on at least a part of the spray program. In 1918 this list had increased to 357. He leads every important orchard operation, as for instance the different sprays, by a circular letter giving a few snappy paragraphs of advice on this particular operation.

ORCHARD CLUB WORK.

One project undertaken in 1918 is worthy of mention. This was a boys' orchard club project carried on in cooperation with one of the boys' club leaders. One of the sprayer companies furnished a barrel sprayer and full equipment for the work. Ten trees were selected in each of the boy's home orchards. A local store furnished spray material at cost. The sprayer was hauled from orchard to orchard in an old spring wagon used as a trailer. The boys helped each other apply the sprays. Deducting cost of spray materials and 25 cents an hour for all labor and 40 per cent of the cost of manure and straw used for mulching the ten tree plots netted from \$35.83 to \$72.94 or an average net per tree of \$5.49. Every boy plans to buy a sprayer of his own for next year and take care of the home orchard. The farm orchard always presents a difficult problem for the pomological extension man. It would seem that a competent orchard man connected with the club department could do a great deal, not only with the home orchard, but with strawberry, raspberry, blackberry, potato, and garden clubs.

WINTER SHORT COURSE SCHOOLS.

The horticultural department has a representative on the winter short course staff. This work runs from about December 1st to March 1st. The success of this work depends to quite an extent on illustrative material. In the past 20x30 inch enlargements were largely made use of to illustrate each point. The work was given in the day time which prevented the effective use of the lantern in most cases. The past winter a collapsible box was made with a 3x4 foot tracing cloth screen in front. The box is

nearly light proof and the picture is thrown on the back of the tracing cloth on the inside of the box. This makes a 40-cent slide as effective as \$4.00 to \$5.00 enlargement.

LANDSCAPE WORK.

Very little has been done along landscape extension lines for the past year and a half, other than to keep the demonstrations already established in good shape.

VEGETABLE GARDENING.

The main activity along vegetable lines through the war period has been to supervise and direct the war garden campaign. Early in 1918 a one-week school for prospective supervisors was conducted by the horticultural department. Later 150 paid supervisors were placed in 106 cities. In addition 65 cities had active garden committees. One man in the division spent all of his time in providing timely material for these supervisors and in conducting district conferences where the supervisors from a number of surrounding cities met and discussed their problems. It was estimated that there were 640,000 gardens in the state of Indiana which produced \$15,000,000.00 worth of food stuffs. One man is now spending all of his time in organizing the garden work for the coming year and is keeping last summer's city organizations from disorganizing.

Other war time vegetable work was a potato seed stock certification survey and the listing and sending out of onion seed information. A potato improvement project is under way for the coming summer which has for its object better seed treatment, seed selection and spraying. This work is to be conducted in co-operation with the county agents in the potato counties by means of demonstration plots with the more progressive growers.

EXHIBIT WORK.

The summer gardening campaign was followed in the fall by a number of pit storage demonstrations. They were put on at the state and county fairs and in the cities which had been taking the most interest in the garden movement. These pits were made of the actual materials in cross section showing the vegetables in the pit and the method of construction. Many of these demonstration pits were constructed in store windows and allowed to remain for a week or more. A supply of storage bulletins was on hand to be distributed by the storekeeper.

Quite an extensive display was put on at the state fair showing timely things along vegetable and pomological lines. In pomology two things were featured; the effect of bees on the fertilization and set of bloom; and the effect of nitrate of soda on the set of bloom.

In the fall when there was the most to be seen from the summer's work in the demonstration orchards, the farmers and growers were so busy that the holding of meetings was not a success. This bids fair in a measure, to destroy the effectiveness of this work. However, it was found that window displays in the nearest town served, to give the results a great deal of publicity. The plan usually followed was to pick all the fruit from one of the uncared for trees and pile it on one side of a prominent store window and on the other side of the window, some of the fruit from the cared-for plots, attractively arranged on trays and plates.

ORGANIZING CANHOUSE TOMATO GROWERS FOR EMERGENCY PRODUCTION.

By R. W. DE BAUN, *Experiment Station, New Brunswick, N. J.*

The tomato growers of New Jersey have been organized less than a year, but in this short period of time the organization has saved the growers of canhouse tomatoes an enormous sum of money, and the amount of tomatoes produced for the emergency need of the army and navy has been increased many thousand tons. This splendid accomplishment was made possible by the peculiar condition of the cannery industry in the state and by the excellent leadership of the county agents and their associates.

The growers in our little state annually plant about thirty thousand acres of tomatoes for the can houses, because the soil and climate are particularly adapted for tomato growing. The growers have always been anxious to produce this crop, as it fits nicely into the cropping system on almost any farm. The ground for the tomato crop need not be prepared until after the potatoes and corn are planted and the tomato plants are set at the convenience of the grower during May and June. The tomatoes are ready to be picked after the hay has been harvested and early white potatoes have been shipped, but before sweet potatoes are to be dug, or corn harvested. Although the growers have always realized that the contract prices offered by the canners were ridiculously low, they refused to estimate their cost of production. Formerly their fields were rich, and tomato diseases were not so destructive as they have become during the last decade. Bitter experience, years ago, has taught the producers to grow their crop under contract, so that when the usual over supply came they were reasonably sure of getting something for their tomatoes.

The packers have taken advantage of this situation. The contract prices offered the farmers have been as low as \$6.00 per ton for first-class red-ripe fruit delivered to the can house. For several years, the prevailing contract price was \$8.00 or less per ton. The result was that the growers were actually giving away the fertility of their soil, and they were underpaid for their labor. Finally, impoverished soils and plant diseases began to cause a reduction in the yield per acre. Fertilizer and labor became more costly, while at the same time the consumption of and demand for canned

tomatoes rapidly increased. Therefore, the growers who did not contract found that their product was in demand on the open market and the men who had contracted soon realized that the cost of production had increased much more rapidly than the contract price. Needless to say, the growers became restless.

Very early in the present year (1918) the Canned Foods Division of the Food Administration notified the tomato canners that the army and navy would require 35 per cent of their pack. The price which the Government was to pay the canner was not to be on a cost plus 10 per cent basis (regardless of cost) as it had been the previous year, but it was to be based on a fair contract price to the grower and allow the packer a fair profit for his factory operations. The amount of canned material produced from a ton of raw material was definitely known and the cost of packing could be easily determined. However, it was a more difficult task to determine what would be a fair contract price to the growers, because definite and accurate records on the cost of producing the raw material were not available for the Food Purchasing Board. The farmers had no representatives at Washington, while the organized canners were well represented at the National Capitol. Then it soon became apparent that the canners were trying to get an exceedingly low contract price allowed for the growers, and the Canned Foods Division would never have had an opportunity to get an accurate idea of the cost of producing a ton of raw tomatoes unless the information was forced through to them regardless of the canners.

The county agricultural agents saw their opportunity to be of great and definite service in their respective counties by getting a fair contract price for their growers, and an increased production for the emergency needs of the Allies, because the canned tomato is a very beneficial and desirable food for use by soldiers as an emergency ration in conjunction with pork and beans, hardtack and coffee. County agents filled the local papers with discussions on the proposed contract prices; they called local meetings in every can house community. The situation was explained, and immediate action was urged. The growers became enthusiastic and were ready to do anything the county agent and his associates requested. A need for county associations became apparent. The county agent arranged for the meeting place, sent out several hundred letters, tacked up posters and arranged for speakers. Large crowds responded to the call in every case. County Tomato Growers' Associations were formed and constitutions were adopted. A membership fee of 50 cents or \$1.00 was required. For each association an executive committee, composed of fifteen leading tomato growers, who represented each section of the county, was selected. The executive committee of the various county associations worked out estimates for the cost of growing and delivering a ton of can-house tomatoes in 1918 in their counties. The estimates for the respective counties were as follows: Camden, \$24.46; Cumberland, \$25.48;

Salem, \$25.60; Burlington, \$27.68, and Gloucester, \$29.54. In every case the estimated cost of producing a ton of tomatoes appeared to be very high, but the figures were found to be accurate when discussed and approved at the next general meeting of each association. Local meetings were continued throughout the counties. The growers responded with enthusiasm. At each community meeting the growers were invited to estimate the cost of production for their immediate neighborhood. Then their estimate was compared with that of the County Association. At every opportunity, the county agent published the results of the meetings in the local newspapers, and the carefully estimated cost of production was given publicity in every possible way. Absolutely no attempt was made to have the growers take concerted action and agree on a price, because such action would have been impossible and also illegal. It was the purpose of the county agents and the leading growers to make every effort to have the growers realize what it was going to cost them to grow a ton of tomatoes in 1918, because they believed there was no reason why anyone should contract to produce an article for less than the cost of production. Besides that, it was the expressed wish of our Government, from the President down, that all should have a fair margin of profit for everything produced for emergency use. Within a very few weeks, the County Associations united and formed the Federation of County Tomato Growers Associations, so that the greatest unity of action could be developed. The Federation represented five county associations with a total paid-up membership of over a thousand growers, who had been made to realize that their probable cost of production would be approximately \$27.00 per ton. Therefore, there was no danger of their signing contracts to produce tomatoes for \$20.00 to \$22.00 per ton, as suggested by the canners.

All this time the interests of the growers in any part of the country had not been represented at Washington. However, the United States Food Administration announced that the Food Purchasing Board for the army and navy was ready to receive tenders from packers for canned tomatoes, based on \$21.00 per ton for the raw tomatoes in New Jersey with graduated lower rates for growers farther from the eastern seaports. The canners, ignorantly or intentionally, tried to make the New Jersey growers believe that \$21.00 was their fixed price. However, the county agents found that such was not the case; the New Jersey canners had simply been invited to tender their bids based on \$21.00 per ton for raw tomatoes. The canners' propaganda work for a \$21.00 contract was quickly exposed. The organized growers of New Jersey immediately sent the President of their Federation before the Canned Foods Division of the United States Food Administration with their cost estimates. This resulted in the Canned Foods Division calling a conference of the county agents from Delaware, Maryland, and New Jersey for February 25. The cost estimates presented

by the county agents represented 89 Maryland growers, 45 Delaware growers and 805 New Jersey growers.

The Canned Foods Division then realized that their proposed figure was too low, and on March 15 they found it necessary to issue an official statement saying that no packer had been required to make a tender to the Government based on \$21.00 per ton for raw tomatoes, but that they were simply invited to do so, as the Food Administration had no authority nor desire to fix the price of tomatoes. Soon after that, the New Jersey packers started to make contracts with the growers. The prevailing price became \$30.00 per ton instead of a much lower figure.

The result of the splendid work done in organizing the tomato growers has been far-reaching. The growers have been adequately paid for their labor. A conservative estimate of the increase in remuneration for the farmers is one million dollars. The production of tomatoes was automatically increased at least fifty thousand tons for the emergency need of the Government. More than two thousand growers were taught the value of estimating the cost of production, and during this last season 160 tomato growers in one county kept accurate account of the cost of producing their crop. Above all, the farmers have been made to realize that the county agents stand for the advancement of the agricultural interests of the county, and that the farmers can accomplish splendid results with his cooperation and by means of organization.

BULB CULTURE IN THE PACIFIC NORTHWEST.

By DAVID GRIFFITHS, *United States Department of Agriculture, Washington, D. C.*

This was a non-technical discussion of the work of the Department of Agriculture in its experiments in Dutch bulb culture at Bellingham, Washington. Thirty views of bulb beds in flower and the different operations in handling bulbs were thrown on the screen. Some of the difficulties in getting comparable factors of yields were pointed out, and the merits of basing computations on increase in the number of bulbs dug, weight of bulbs, and the area of land planted in two consecutive years, were brought out.

This address will be included in a bulletin on bulb culture to be published soon by the United States Department of Agriculture.

NOTES ON GERANIUM BREEDING.

By W. R. BALLARD, *Maryland Experiment Station, College Park, Maryland.*

"The geranium" of the garden is not a geranium botanically but belongs to the genus *Pelargonium*. The bedding type which is the one most commonly seen in this country belongs to the zonal race. This is apparently derived from *P. zonale* and *P. inquinans*. As a group it is quite variable with a wonderful range of colors in the showy flowers. The flowers are of two types, the two-lipped

with petals separated and the circular with petals broad and overlapping. There are also single and double races. The season of bloom is nearly continuous with most varieties although many of the ornamental leaved varieties produce little bloom.

The Show, or Lady Washington type seems to have descended from *P. cucullatum* and *P. angulosum*. Its limited period of bloom and its inability to withstand hot weather conditions have prevented its extensive use for bedding purpose. The flowers are so large and so gorgeous in color that varieties which could be used for bedding purposes would be extremely desirable. Recently an everblooming strain has made its appearance which gives promise of extending the season of bloom.

The scented-leaved type includes a number of species. Some of these have been important sources of perfumes, notably the rose geranium which has furnished an essential oil formerly used as an adulterant of attar of roses.

Another type occasionally seen in greenhouse and conservatory in this country is the ivy-leaved section. This is usually referred to *P. pellatum*. The plants are mostly trailing in habit with large velvety flowers.

During the winter of 1907 the writer became interested in a study of the geranium in relation to its improvement as a bedding plant. The work here reported upon was conducted as a side line to other breeding projects with orchard fruits. While not carried far enough to accomplish very definite results, still these results and observations seem worthy of record and may serve to point out lines of investigation which those with the requisite time and facilities might find interesting and profitable. The material used in this project consisted of about 125 named varieties of the zonal group and a few plants of the Lady Washington and scented-leaved sections.

DISEASE RESISTANCE.

During the hot, moist summer seasons so prevalent in Maryland many varieties of the geranium are seriously injured by a leaf spot which spreads to the stems and often kills the entire plant. In occasional dry seasons practically all varieties flourish and bloom profusely. In co-operation with Mr. T. H. White, floriculturist of the Experiment Station, a series of tests was made to determine the relation of the moist conditions to the prevalence of the disease. One lot of plants including nearly 100 varieties was set where the plants would be protected from rains by wide overhanging eaves. A duplicate lot was set in the open ground for a check. After a three years' test it was determined that the keeping of the foliage dry afforded an almost complete prevention of the leaf spot.

In the open ground there was a marked variation in the ability of the different varieties to resist the leaf spot. Most of the varieties which are extensively used for bedding have evidently been selected somewhat in relation to this disease since they exhibit a

marked resistance to it. In addition several varieties not usually found outside of greenhouse and conservatory were found to be resistant. In these varieties, however, the color of the flowers or the type of bloom was not desirable from a bedding standpoint. Many varieties with attractive flowers are so susceptible to disease that it is impossible to succeed with them as bedding plants.

With a view to enlarging the list of desirable bedding sorts work was begun to combine disease resistant types with those having desirable blooming habit and desirable colors in the flower. It was particularly desired to secure plants with double flowers since the single flowers shatter badly in the Maryland climate. Because of a limited number of plants of each variety in bloom at any time it became necessary to make a large number of crosses. Consequently the number of seedlings secured from any one cross was small.

The geranium is a plant easily worked with as the anthers shed their pollen and fall off usually before the stigmatic surface is exposed. The danger from self pollination is therefore relatively small and the tedious operation of emasculation is obviated. Even cross pollination is rare in the greenhouse during the winter season although in early spring insects are occasionally responsible for carrying the pollen from one flower to another.

Several hundred seedlings have been grown, but the greatest difficulty has been encountered in the attempt to combine the disease-resistant character with the flower characters which would make them of special value for bedding. One seedling with brilliant orange-scarlet, semi-double flowers of good form resulted from a cross between Paul Ricard and La Pilote. This was introduced to the trade in 1913 by Richard Vincent, Jr., & Sons, Whitmarsh, Maryland, under the name of Maryland. Since that time, however, it has proved to be less resistant to disease than was at first supposed and for that reason is not expected to retain a place as a bedding variety. In this connection it is worthy of note that seedlings exhibit unusual vigor of growth for the first year or two and this may easily mislead one in his estimate of the value of a new variety.

Because of the hybrid nature of most varieties considerable segregation takes place in the F_1 generation. A tabulation of the results from one season's crop of seedlings in relation to the form of the flower gave the following totals:

Singles x singles gave 84 singles and 6 doubles.

Singles x doubles gave 59 singles and 74 doubles.

Doubles x doubles gave 40 singles and 30 doubles.

In the course of this work an interesting example of correlation came to light. One of the characters in the *Pelargonium* which is often used to distinguish this genus from the true *geranium* is the nectar tube adnate to the flower stem. In the zonal group this tube does not appear to be a constant character. It is apparently correlated with the single flowering character as the

majority of the double flowering sorts are without this nectar tube. Of 55 varieties observed nectar tubes were found well developed in 12 single flowering sorts and partially developed in four others. They were entirely wanting in 38 double flowering sorts.

An attempt was made to hybridize different species but little success has attended this work. The zonal group and the ivy-leaved section will hybridize but the hybrids are not very fertile. It is also possible to combine the Lady Washington type with some of the scented leaved types, but the zonals will not hybridize with either the show or the scented leaved groups. It might be possible to utilize little known species in developing greater resistance to disease and to bridge over this gap between groups. The scented leaved section offers some interesting possibilities in the production of perfumes and a chemical study of the essential oils in the glands of the different species and their behavior in hybridized seedlings might give important results.

SATURDAY, DECEMBER 28, 9:30 A. M.

FIVE YEARS' RESULTS IN PLUM POLLINATION.

By A. H. HENDRICKSON, *University of California,
Berkeley, California.*

The results, which are summarized below from the paper presented at the Baltimore meeting in 1918, were obtained by the Division of Pomology of the University of California as a result of five years investigations on the problem of plum pollination. In these investigations all effort was directed toward obtaining data which would be of immediate assistance to the grower who had a plum orchard either in reality or in contemplation. Various fundamental problems underlying the causes of sterility in this fruit were postponed until time and facilities would permit of their study.

Something over 100,000 hand pollinations were made to determine the effects of selfing and crossing; and something over 175,000 blossoms were counted to secure the per cent of set under normal orchard conditions. These large numbers were used to make the data as reliable as possible. The results obtained in most cases were clear-cut, and furthermore, were consistent throughout the five years. Results, about which there may be the slightest question, are reserved for a later publication, where space will be available for their discussion.

Eight varieties of Japanese plums and nine varieties of the European type were tested with the following general results:

The Japanese varieties, Combination, Kelsey, Satsuma, Burbank, Wickson, Sultan and Abundance are self-sterile. The Climax is evidently self-fertile or at least partly so.

Among the European plums and prunes Clyman, Tragedy and Robe de Sergeant are clearly self-sterile. Imperial, although occasionally setting fruit with its own pollen, is too uncertain to be classed commercially as anything but self-sterile.

Grand Duke is probably self-sterile.

Pond and Yellow Egg were only tested for sterility for one year so definite conclusions cannot be drawn.

The French (Agen) and Sugar prunes are undoubtedly self-sterile.

No inter-species crosses were attempted.

No cases of inter-sterility, either in the Japanese or the European plums, were found.

The Japanese plums effectively cross-pollinate one another, depending somewhat on the coincidence of the respective blossoming periods. The same is true for the European plums.

Full discussion and data will be presented in a forthcoming bulletin to be published by the California Agricultural Experiment Station in the near future.

THE RELATION OF TIME OF BLOOMING TO RIPENING PERIOD IN PEACH VARIETIES.

By J. B. S. NORTON, *Experiment Station, College Park, Maryland.*

Whether early flowering peach varieties ripen their fruit earlier than late flowering kinds or vice versa, has no doubt often been considered and conclusions reached based only on a few varieties. I have at various times discussed this question with different peach growers and the general opinion seemed to be that the early bloomers ripen late and the late flowering kinds ripen early.

Seeing the tabulation of blooming and fruiting periods of 179 varieties in Hedrick's Peaches of New York, I thought this might give enough data to settle the question, and so prepared the following tables from that source, the figures giving the number of varieties in each group.

TABLE I.

Blooming Period	RIPENING PERIOD.					Total
	Very Early	Early	Medium	Late	Very Late	
Very early.	0	0	1	0	0	1
Early	3	4	13	3	2	25
Medium ...	3	15	53	43	15	129
Late	1	1	6	7	5	20
Very late..	0	0	1	1	2	4
Totals ..	7	20	74	54	24	179

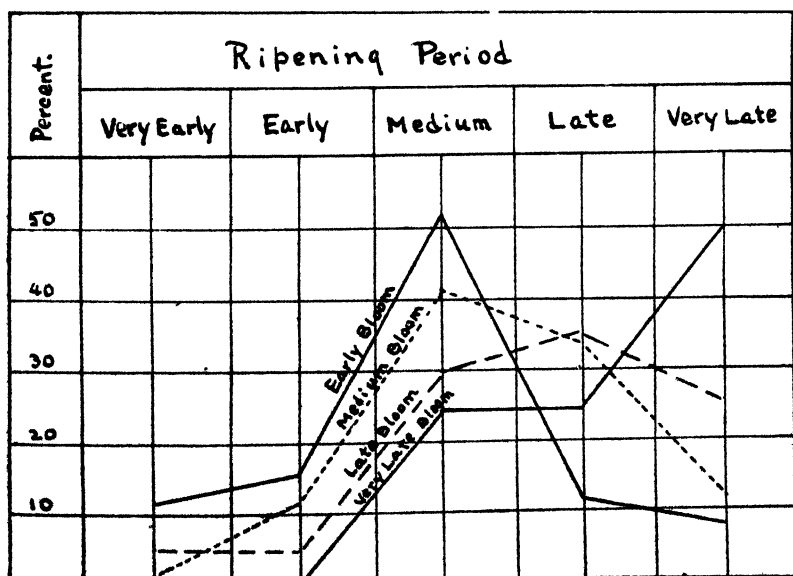
The above tabulation shows the number of peach varieties for each blooming period ripening as indicated under the heading "ripening period."

TABLE II.

Blooming Period	RIPENING PERIOD.				
	Very Early	Early	Medium	Late	Very Late
Very early.	0	0	100	0	0
Early	12	16	52	12	8
Medium ...	2	12	41	33	12
Late	5	5	30	35	25
Very late..	0	0	25	25	50

This table shows the data of the previous table in percentages of the varieties blooming in each period.

The very early and very late varieties are too few to give accurate information, but are in general in line with the others. Although there are plenty of exceptions, in the majority of cases, the later the blooming the later the ripening, as is shown graphically in the following chart.



The lines indicate the percentages of varieties of four bloom-periods ripening at different times, the percentages rise higher toward the left the later the blooming period.

HORTICULTURE AND THE WAR.

By C. A. McCUE, *Delaware College, Newark, Delaware.*

This, our fifteenth annual meeting, will prove to be a memorable one in our history as a Society. We are just emerging from a period of mental, physical and economic stress that has tried the very souls of men. We are now having our first opportunity to compare notes as to the effect of the World War upon horticulture, an industry that was meant for peaceful days. We are all asking ourselves, did we measure up to our opportunities and our obligations, not only as individuals, but as exponents of one of the oldest of professions. Have horticulture and horticulturists been of direct benefit in winning the war? Have we as a professional class served our country to the best of our abilities? It is impossible to give an accurate statistical answer to these questions. It is perhaps too soon after the great conflict to get a proper valuation and clear viewpoint of our work. A few years hence we shall be able to more accurately evaluate our efforts.

Correspondence with heads of the several horticultural departments has shown that their wartime efforts have fallen into several rather distinct lines. Let us first consider what I shall call our non-professional efforts. Under this head we group such things as mark a man in his community as a citizen, rather than as a professional man. Here I think that we have no cause for complaint as to the type of men who have chosen horticulture as their life work. In practically every state the men who belong to our profession have been actively identified with wartime community efforts such as Liberty Loan drives, Y. M. C. A., Red Cross and allied campaigns to finance the prosecution of the war and to alleviate mental and physical suffering among men in arms at home and over seas. Common stress tends to make all men brothers, and it has been gratifying to find that many of those in our ranks have developed into leaders in their home communities. To be good citizens does not merely mean paying taxes and keeping out of jail. Citizenship means service, and the records show that horticulturists as a class have not been at all backward in offering and giving non-professional service to their country and their fellow-men.

The following is a list, as far as I have been able to compile it, of those members of our profession who have been engaged in special lines of war work:

SPECIAL WAR WORK.

MICHIGAN	H. J. Eustace, Food Administration.
PENNSYLVANIA	S. W. Fletcher, charge of Horticultural Instruction, A. E. F.
IOWA	C. L. Fitch, Y. M. C. A. work.
CALIFORNIA	W. L. Howard, member of State Committee on Food Survey.
	J. C. Whitten, County Chairman, Red Cross Membership Committee, on Liberty Bond Committees, Red Cross and Y. M. C. A. Drives.

TEXAS	E. J. Kyle, Chairman of War Fund Drives and Community Food Administrator.
NEW HAMPSHIRE.....	J. H. Gourley, State Supervisor of War Gardens.
KENTUCKY	C. W. Matthews, National Bureau of Education on School Garden Work.
VIRGINIA	T. C. Johnson, County Food Administration Board, and Thrift Stamp and Liberty Bond Committee.
WASHINGTON	D. R. Hull, Special War Board on Development of Cantonment and Hospital Grounds.

At this point it might be well to record the names of those of our profession who have offered their bodies as a living sacrifice at the altar of their country. Many others would gladly have gone forth at the call of arms if it had not been for physical disqualifications, dependant families and a feeling that they could be of more service to their country by remaining at their tasks. The wheels of peace must be kept well oiled if the mills of war are to grind efficiently. I am sorry that I have not been able to secure information that would make the list complete. Letters were sent to all the states, but from some no replies have been obtained. My thought in compiling such a list was that we might have a permanent record of those who served their country along military lines. In some cases we were unable to obtain names, in others no rank was given. In many other cases the professional rank of the man was not given. I have endeavored to include only those of the rank of Professor, Associate Professor, Assistant Professor, Instructor, and Graduate Assistant. The record for the Dominion of Canada is I am sure very incomplete. The list is as follows:

MEN IN MILITARY OR NAVAL SERVICE.

CANADA (Guelph)	G. J. Cullan, Lieutenant, Canadian Expeditionary Force.
Dominion Experimental Farms.....	W. Dreher, Lieutenant, Canadian Army. M. B. Davis, Sergeant, Canadian Army.
CALIFORNIA	V. W. Hoffman, Second Lieutenant, Aviation Corps. Lee Foster, Captain. Harold Gaymon, Lieutenant.
COLORADO	J. C. Hoffman, Lieutenant. G. F. Limbocker, Captain, A. E. F.
GEORGIA	T. H. McHatton, Captain, Bureau of Aircraft Production. J. W. Firor, First Lieutenant, Artillery, A. E. F. C. N. Keyser, Ensign, Naval Aviation.
IDAHO	G. J. Downing, Captain, Field Artillery.
INDIANA	C. B. Sayre, Lieutenant-Colonel. C. G. Sauers, Captain, A. E. F. R. A. Nehf, Second Lieutenant. W. M. Richards, Captain, A. E. F.
IOWA	W. E. Whitehouse, Second Lieutenant, Aviation. H. E. Nichols, Officers' Training Camp. T. J. Maney, Gardening Work at Base Hospitals. E. A. Prester, Second Lieutenant, Infantry, A. E. F. P. P. Stonecifer, Officers' Training Camp.

	F. M. Harrington, Officers' Training Camp.
	H. Hartman, Intelligence Department.
	R. J. Pearse, Flying Cadet.
MARYLAND	F. S. Holmes, Second Lieutenant, A. E. F.
MASSACHUSETTS	G. S. Watts, Navy.
MICHIGAN	J. H. Carmody, First Sergeant.
	W. T. Moore, First Lieutenant.
	R. W. Peterson, Private.
MINNESOTA	W. D. Valleau, Sergeant, Medical Corps.
	F. A. Krantz, Second Lieutenant, Quartermasters Corps.
	F. P. Daniels, Cadet, Balloon Service.
	W. T. Topley, Second Lieutenant, Motor Transport Corps.
	W. J. Koppen, Aviation Mechanic.
	H. J. Beaumont, Aviation Mechanic.
	J. H. Bushnell, S. A. T. C.
MISSOURI.....	W. H. Lawrence, Captain, Educational Department, Medical Corps.
NEBRASKA	F. G. Grossart, Officers' Training Camp.
NEW HAMPSHIRE.....	J. R. Hepler, Second Lieutenant, Quartermasters Corps.
NEW JERSEY.....	D. Schmidt, A. E. F.
NEW MEXICO.....	J. M. Franklin, U. S. Navy.
NEW YORK (Geneva) ..	G. H. Howe, Sergeant, Medical Corps.
NEW YORK (Cornell) ..	Paul Work, Lieutenant, A. E. F.
NOVA SCOTIA.....	W. T. Blair, Signal Corps, Canadian Army; wounded.
	M. J. Robinson, Camp Sanitary Inspector, Canadian Army.
	James Gallahar, Transport Service, Canadian Army.
OHIO	P. H. Elwood, Captain, Field Artillery, A. E. F.
	F. E. Allen, Lieutenant, Reconstruction Hospital.
	B. D. Drain, Officers' Training Camp.
	F. H. Beach, Officers' Training Camp.
OKLAHOMA	C. W. Rapp, First Lieutenant.
OREGON.....	H. D. Locklin, Radio Service, Navy.
	Mr. McCormick, Quartermasters Corps.
PENNSYLVANIA	W. C. Gillespie, Captain, Field Artillery.
	A. F. Mason, Coast Artillery, Officers' Training School.
	J. B. Scherer, First Lieutenant, Field Artillery, A. E. F.
	E. I. Wilde, Second Lieutenant, Gardening Work, Base Hospitals, A. E. F.
RHODE ISLAND.....	P. E. Corriveau, Lieutenant, U. S. Marine Corps, A. E. F.; killed in action.
SOUTH CAROLINA.....	George P. Hoffman, Officers' Training School.
	George E. Prince, Officers' Training School.
	C. C. Vincent, Second Lieutenant.
VIRGINIA	Kent Aperson, Sergeant, Medical Corps, A. E. F.
	Albert White, Officers' Training Camp.
WEST VIRGINIA.....	W. R. Legge, Second Lieutenant, Artillery, A. E. F.
	R. H. Patch, Private, Ammunition Train.
UNITED STATES DEPARTMENT OF AGRICULTURE	Beckerman Bernard, Draftsman in the Chemical Service (Gas Defense).
	Edward B. Benson.
	Ralph E. Caryl, Base Hospital.
	George M. Darrow, Sergeant, Reconstruction Work.

Sidney H. Davidson.
Albert F. Edminster.
George L. Fischer, Second Lieutenant, Artillery.
Melvin C. Hobson, Science and Research Division,
Aviation Section; in France.
Kirtley B. Lewis.
John R. Magness.
F. E. Miller, First Lieutenant, Subsistence Division,
Quartermaster Corps.
Edgar W. Montell, Second Lieutenant, Infantry.
Arthur E. Nelson.
H. E. Newman
J. R. Price.
Vincent W. Ridley.
Vincent G. Ryan.
C. E. Schuster, Second Lieutenant.
R. C. Severance.
Otis E. Simpson, Sergeant, Medical Corps.
Edwin Smith, Chief Boatswain's Mate, Navy,
Officers' Medical Naval Operating Base, Hampton Roads, Va.
H. F. Smith.
Samuel L. Van Orman, Second Lieutenant, Quartermasters Corps.
E. D. Vosbury, First Lieutenant, Air Service; in France.

The list of men in military service is one to be proud of when we consider that the majority of these men were occupying positions where they no doubt could have, in the majority of cases, secured deferred classification if they had so desired.

As regards the professional work of the various horticultural departments throughout the country, we find that in the majority of cases the regular routine programs were greatly disorganized. War work took precedence over all other endeavors. In a few states horticultural work as a unit was practically discontinued, the men of the department being shifted to emergency work. In other cases the efforts of the department were directed to lines of work that had previously occupied but little of the department's time. This was especially true in the case of vegetable growing. The war has brought home to us in a most emphatic manner that we as horticulturists have been neglecting the vegetable industries of our country. Only a few of the colleges and stations have separate divisions of vegetable gardening. Yet in the stress of war and in the great need for increased food production, we have found that vegetables were one of our greatest of food supplies. In practically every state the horticultural departments have thrown their energies into a campaign for greater vegetable production. The lesson that we have learned regarding the importance of vegetable gardening is one that we should not forget. We have had forced upon us the great need for better experimentation and more fundamental investigational work with vegetables. We realize as never before the great need for standardization of vegetable varieties and the necessity for thorough research along the lines of inheritance and fixation of valuable characters in vegetables.

May I interject here a plea for research along the lines of genetic inheritance of factors that go to make up the characters of our common vegetables. I venture to assert that if we had possessed this information three years ago that our vegetable production would have been doubled over what it was in wartime. The war has also shown us that we as a nation ought to produce our own vegetable seed and not be forced to depend upon foreign importations of seed in order to maintain our output of vegetables. In this connection it might be well to note that one Canadian Department of horticulture produced last year 30,000 pounds of turnip seed for the Dominion Government. However, what we need is not so much more vegetable seed but better seed. We can not hope to attain a high standard in vegetable production until we have taken up vegetable breeding in earnest and concentrated our efforts upon the production of better varieties. We cannot hope to produce better varieties until we know how to sift out undesirable characters. We have here a great field for research that is practically untouched. We have studied the effects of environment upon somatic characters, but we have sadly neglected the germinal characters of our vegetables.

The influence of the war upon fruit production has not been nearly so marked as in the case of vegetable production. It has emphasized however the great need for better methods of control of our insect and fungous enemies. War has taught us the need for better spraying. War conditions have also shown us the vast field for research that we have before us along the lines of utilization of fruit products. It has shown us the great source of food that lies in our cull fruits. The manufacture of fruit by-products has received a magnificent impetus. Let us put our shoulder to the wheel and help such industries to a firm peace-time foundation.

Dehydration has under the stimulus of war become more than a mere name. Thousands of tons of fruit and vegetable products that under normal conditions would have gone to waste, have been saved through dehydration.

A greater interest in fruit and vegetable storage has been stimulated by the war. Cold storage problems are nearer solution than they have been before. The great value of home storage has been brought home to us.

One of the great results of the war has been its effect upon the diet of our people. We have by necessity learned the great lesson of the value of fruits and vegetables in our every day menu. I doubt if we ever again become the great meat consuming nation that we were. Fruits and vegetables upon our tables have come to stay. This fact alone should give a great impetus to fruit and vegetable growing, and in closing I feel safe in saying that because of the war the business of growing fruits and vegetables is upon a sounder foundation than it ever was before.

DEVELOPING NEW GRAPE INDUSTRIES.

By GEORGE C. HUSMANN, *U. S. Department of Agriculture,*
Washington, D. C.

During practically the same years that the grape growers on the Atlantic Coast were unable to account for their failures, with the vinifera varieties which they brought from Europe, owing to the fact that they were in blissful ignorance of the omnipresence of the *Phylloxera Vestatrix*, or root louse, of the vine, (and it was not until they turned their attention to the growing and improving of our native grapes, that success crowned their efforts), the mission fathers were founding the Missions west of the Rock Mountains and planted at these olives, figs. and grapes, and incidentally became introducers and pioneers in the growing of these three important fruits and demonstrated California to be a congenial home for Vinifera grapes.

The Mission Fathers grew only one variety, the Mission, (a true vinifera) which for many years was the most important grape grown in California and is at present grown to some extent in some districts.

In the South Atlantic and Gulf States, the growing of the Rotundifolia continues in the embryonic state, just because these vines grow and fruit with little or no care and are resistant to Phylloxera and even make a brave stand against rot, mildew, and numerous other evils that beset vines.

A few years of research work with Rotundifolia grapes, outlined by the writer, not only proved the fallacy of the general belief that to prune Rotundifolia would kill them, but proved that pruning was absolutely necessary for best results and that by pruning not only was better fruit secured, but it also enabled the ripening of fruit in clusters. Some of the vines experimented with were more than 50 years old, when the first pruning they had ever had, was given them and the vines were restored to complete vigor and fruitfulness.

The vines of the Rotundifolia species were thought heretofore to consist of either fruiting vines that were practically self sterile, or plants producing flowers having both stamens and pistils in which the female organs were capable of producing fruit if fertilized by pollen from male or staminate vines. In grape breeding work with these in less than a decade, we produced self fertile strains, from which quite a progeny of self fertile vines have since been grown. This fact in itself makes possible the revolutionizing of the Rotundifolia grape industry, by putting it on a self fertile basis.

The present viticultural industry in the Vinifera regions of the United States now represents an investment of at least \$300,000,000.00, gives employment to 15,000 persons and yields an income of more than \$50,000,000.00 per annum.

In these Vinifera regions the earlier grape growing activities were almost exclusively devoted to the growing of wine grapes and

although introductions of all the choicer vinifera varieties were made early in the last half of the last century, including raisin, table and shipping varieties, it was not until 1873, that raisin crops became an important factor in the market, the entire output that year amounting to 6,000 boxes. Since then the industry has grown so that last year the enormous quantity of 310,000,000 pounds of raisins were cured and about 25 per cent of these were exported.

Eighteen years ago when Phylloxera, the-so-called California Vine Disease, and other agencies, threatened to wipe out the entire vinifera grape industry, the United States Department of Agriculture came to the rescue and began broad viticultural research work. This lead up to a number of special investigations, some of which have been worked out as a result of which we are now busy in starting some important new grape industries.

One of the important lines of work in the viticultural investigations of the United States Department of Agriculture has been the introducing from various parts of the world and testing of grape varieties thought to be of value to viticulture and ascertaining their value and usefulness for diverse purposes in this country.

The first grape variety that reached the United States Department of Agriculture after I did was the Panariti (S. P. I. No.) one of the varieties from which was currants of commerce are produced.

In the currant grapes three colors, white, red and dark are found.

The Corinthe grape experiments made by us are with Corinthe blanc, Corinthe rose, Black Corinthe and the Panariti varieties. Of these the Black Corinthe has proven worthless. No one appears to have had any particular trouble in fruiting the Corinthe blanc and Corinthe rose, but their fruit is inferior in quality, both fresh and dried, as compared to the Panariti, for which reason special researches relative to the latter were made.

The introduction of the Panariti consisted of a medly of old and young wood of miscellaneous lengths, thrown loosely without packing into a wooden roughly sealed box.

Of this the one year old wood was cut into cuttings and a distribution made of a portion of these to grape growers, who, it was thought, would take some interest in it, which accounts for the occasional plantings of it in California.

It may interest you to know some of the cuttings were used to make an experiment of testing how long cuttings could be immersed in hot water of different degrees of temperature without killing them. A portion of these immersed cuttings were afterwards planted in nursery in the usual manner, and a portion of them cut into one eye cuttings, placed in sand in greenhouse and given bottom heat. The results showed that of shipments of grape cuttings arriving in a somewhat dry condition those immersed ten minutes in water brought to 53°C. or 127°F., were put in better condition than those immersed only 5 minutes at the same tem-

perature, and by immersing them 5 minutes at 56°C. or 133°F. best results were obtained. whereas, at 60°C. or 140°F. an immersion of only 5 minutes was not only injurious, but largely fatal to the cuttings.

Because of the important part this variety is destined to play in the viticulture of this country, the following description of it is given. Vine a vigorous, dense, slightly spreading grower. Young wood medium slender, round; internodes medium long, thin; nodes slightly enlarged; buds prominent, pointed, start early; pith large, discontinuous at diaphragm; tendrils intermittent, forked; canes light brown, striped, smooth; growing tips reddish and hairy. Leaf medium size, oblong, cordate, five lobed, margin serrate, petiolar sinus deep, narrow, usually overlapping; upper leaf surface dark green with lighter colored veins; lower surface lighter green slightly pubescent; petiole medium slender, slightly enlarged at base. Blossoms entire, small, open early; stamens upright, longer than pistil. Blooming period medium, blossoms abundant.

Clusters on ringed vines, medium, compact, cylindrical, medium length, narrow, prominently shouldered, often winged. Berries small, usually less than $\frac{1}{4}$ inch in diameter, adhere well, globose, color grizzly to black with light colored bloom, surface smooth; skin thin, tender; flesh pearly white, soft, juicy; seedless. Flavor rich, characteristic, very high in sugar and relatively high in acid. Excellent in quality, both as a fresh fruit and dried. Ripens very early from July 15 to August 15 and usually produces a slight second crop of berries with seeds.

The resistant stocks so far found most congenial to the Panariti are Rupestris St. George, Aramon x Rupestris Ganzin No. 1, Riparia x Rupestris No. 3309, Mourvedre x Rupestris No. 1202, Adobe Giant, Riparia Gloire, Dog Ridge, Taylor, Narbonne, Lenoir, Salt Creek, and Solonis x Riparia 1616, in the order named. Besides these there are a number of others it does well on.

This variety also readily adjusts itself to different pruning methods and training systems.

When the vines under test had fruited several seasons it was found, however, that one good crop of fair fruit might be obtained from the Panariti, but this could not be depended on and in fact was exceptional.

The literature on the currant grapes shows that ringing the vines is practiced by the growers in the currant producing countries, but the secret, of how and when this is done, is so closely guarded that even its necessity is not mentioned, neither were the Department's agricultural explorers able to extract any real information on this question.

The fact of occasional crops without ringing puzzled us and we likely had decided results in ringing before we knew it, but it took six years of close study and experimentation to determine that to get regular annual crops, not only must the vine be annually ringed, but for this to have the desired effect, it must

be done while the vines are in bloom. Ringing increases the output very greatly and improves the size, quality and quantity of fruit.

Ringing consists in making two parallel cuts through the bark and cambium layer, around either the trunk, arm or canes of the vines, and completely removing the strip of material between the two parallel cuts. This must be thoroughly and completely done, otherwise entire effects of the ringing are not had.

Ringing does not prevent the main upward flow of the sap, but does act as a barrier on the returning downward flow of the sap, which appears to have the effect of retaining and developing the berries on the bloom clusters.

Our experiments further show that the ringing to be effective must be done during the blooming time of the vines. Best results were had when part of the blossoms had opened, or practically in the midst of the blooming period. As the blooming period extends over a limited number of days only when ringing is done on an extensive scale it is advisable to start as the flowers begin to open.

As to the width of the ringing, this should not be any wider than is absolutely necessary to do it thoroughly, so that the healing over may be accomplished in no longer than 6 to 8 weeks or by the time the fruit ripens. On vines from 8 to 10 years old where the ring was no wider than $\frac{1}{4}$ inch, the healing was invariably nicely accomplished. The importance of this and the effects on the plants is at once apparent, especially when in order to get full effects of the operation the trunks of the vines are ringed. It is not of the same consequence where the arms or canes only of vines are ringed, such parts of vines, being renewed by new growth.

The foregoing recital of some experiments with the Panariti shows that the way has been paved for establishing in this country a very extensive and important new grape industry.

Previous to the war, the annual importations of dried currants into this country amounted to over 30,000,000 pounds, or the equivalent of at least 100,000,000 pounds of fresh grapes. Therefore, a market has already been established for that quantity and no doubt, as has been done with other raisins, our consumption of currants can be very materially increased. Furthermore, they are seedless and of exceedingly rich and delicious quality, and ripen so early that other grapes of even mediocre quality are scarce to be had, and it appears, therefore, a fine demand for them as a fresh fruit can be established.

Their ripening so early will enable growing them as an advance crop in the raisin sections of this country and the same labor employed in harvesting and curing currant grapes can cure the other later raisins. It is also a great advantage in growing grapes for drying purposes to be in a district which permits sun drying. The early ripening qualities of Panariti indicate that in all the present *Vinifera* grape districts of this country there are suitable conditions for the growing of currant grapes. Protection against the dew at night will likely be necessary in some of the

coastal districts, but it is preferable that the currants, while drying, be shaded during the great heat of the day, so the same shelter will do for both purposes.

The Ohanez, another grape variety that was among the early California introductions, was never grown to any extent in this country, neither did any one seem to appreciate its value until the United States Department of Agriculture found it adapted to some of the conditions in our *Vinifera* regions, and as the variety is not self-sterile, had ascertained the pruning, training, and other treatment needed to get good results from it. These researches were made with a special introduction, "S. P. I., No. 27362," of Ohanez cuttings made at the writer's request, received March 10, 1910. Then plants and material for propagation were furnished the more progressive grape growers.

Special attention was also called to the extraordinary carrying and keeping qualities of its fruit that led to the establishment of the important Almerian grape shipping industry of grapes packed in cork dust in barrels. Large consignments of these reach the important cities of this country every year.

We hear that of fruit of this year 362,825 barrels, containing an average of 50 pounds of grapes each, have already been consigned to this country.

There appears no reason why Ohanez grapes grown in America, packed in American red wood, *Sequoia sempervirens*, sawdust (the latter being an excellent substitute for cork dust), should not supplant these.

The following is a brief description of the Ohanez: Vine vigorous, robust, and spreading. Canes light brown with darker stripes, stocky, slight, irregular; internodes medium length. Young shoots rather light green, heavy at base, thin near the tips; frequent laterals, tendrils strong, discontinuous. Leaves medium to large, five-lobed, glabrous above and underneath, veins lighter green above; teeth angular, rather light green. Petiole light green, rather short, stout.

Cluster above medium to large, compact, tapering, somewhat blunt at terminal; peduncle light green, long, hard, woody, thick; pedicle short, stout, warty; brush large. Berries above medium to large, oblong, yellowish green, often distinctly veined with sometimes a slight blush on sunny side; flesh crisp, firm, adhering to the skin; skin thick, tough. Seeds, none to 4. Flavor pleasant. Ripens very late.

Good results have so far been had with it on the following phylloxera resistant stocks—Aramon x *Rupestris* Ganzin No. 1, Dog Ridge, *Riparia* x *Rupestris* No. 3309, *Rupestris* St. George, Constantia, Solonis x *Riparia* No. 1616, and *Riparia* x *Rupestris* No. 101.

The parallel system of training so extensively used in Almeria has not proven well adapted to it in the hot interior valleys in our *Vinifera* regions.

Excellent fruiting results are obtained in training it to an ordinary two-wire trellis, wires $2\frac{1}{2}$ to 4 feet above the ground, with single trunk vines having either 2 or 4 arms, and pruned to either canes and long spurs, or long spurs. Very good fruiting results are also obtained with single trunk vines trained to trellis as mentioned on which canes are annually pruned long, preferably canes with laterals being selected and the laterals spurred in pruning. Good results were also had with vines thus pruned and trained to a Munson trellis.

While the variety is not capable of self-fertilizing itself in the Department's experiment vineyards, there are so many other varieties blooming at the same time that no trouble was experienced in this regard. Where extensive plantings of straight Ohancz are contemplated, the interplanting of a pollinizer is suggested. For such purpose the Castiza so extensively used in Almeria is recommended for this purpose. This is a red-colored variety belonging to the same class and is itself a handsome and valuable shipping grape that has been found to be a good regular cropper.

Another point well worth noting is that two district strains developed from the introductions of the Ohancz, both strains being equally fruitful, of like vine and foliage and bearing fruit alike in every respect, except that on one the berries are nice and clean, whereas, on the other, the berries almost invariably have dingy markings on the sunny side which very much detract from their appearance.

Because of this fact, in the distributions of material of it made by the Department, only such as came from vines having the unblemished berries, has been sent out.

There is another fresh grape market which we are making efforts to interest our grape growers in, namely, that of the fancy grapery-grown grapes which find their way to us from across the Atlantic where the growing of these grapes is an extensive business. This market is now somewhat limited because of the exceedingly high prices at which such grapes need to be sold to cover the expense of growing them under glass. We find that these same varieties of grapes can be successfully grown out of doors in this country.

We have demonstrated that the choicest of these varieties yields abundant crops of the choicest fruit with us under ordinary outdoor culture. If proper storage facilities be provided in our larger cities where such grapes are to be sold, it is reasonable for these grapes to be thus kept and taken out of storage and immediately put on the consumers' table. If only one-third the price paid for the imported grapes were obtained for the home grown ones, very handsome returns should be realized.

Another line in grape growing in which we are much interested is to bring about the growing and sending to our markets table grapes of real merit and fine quality, instead of the varieties almost exclusively used at present, that are large and showy in appearance but of most inferior eating quality. It is reason-

able to expect that as soon as our people have once tried the choicer quality grapes and learn to know them, the market for them will be established.

Much ado is being made the last few years about growing vinifera grape varieties in the Eastern States of this country. I certainly do not want to discourage those making the experiment, but do wish to call attention to a few important points that these recent experimenters are either not aware of or at least never allude to, which should be considered to avoid breakers ahead.

1. Every prospective grower of vinifera grapes, should inform himself on the particular vinifera he desires to grow and whether it be suited to the locality in which they are to be grown.

2. He should know the resistant stock suited not only to his soil and location, but such stock must also be congenial to the vinifera he expects to grow on it, for be it remembered, either a stock not adapted to the soil and location or the use of one that is not congenial to the variety to be grown on it, spells failure.

3. The adaptability of phylloxera resistant stocks to soil, climatic, and other conditions can be very closely foretold.

4. The resistant stocks congenial to vinifera varieties needs to be ascertained by actual test. In hundreds, I might say thousands, of tests of this kind made, good crops of vinifera grafted on other stocks are frequently gotten the first few years only.

5. Vinifera varieties although generally speaking are more susceptible to fungous diseases, they often adapt themselves to a number of soil conditions, but of their resistance to cold but little is known.

The cost of establishing vinifera vineyards on phylloxera resistant stocks is practically twice that of vines on their own roots, and if the proper care and attention be not given the grafted vines, if for instance the roots starting from the grafts are allowed to grow and are not kept cut off, non resistant vineyards are the result.

7. In conclusion may I venture a plea for us to also continue our interest in improved varieties of our Native American *Euvitis* species. It is undoubtedly true that the poor results and decline of many of our American *Euvitis* vineyards are not due to soil, location, or climate, but due to our expecting a variety of a species, which species naturally grows and has adjusted itself to a certain, soil, location and climate conditions, to thrive in entirely different ones. Thus the greater number of our American *Euvitis* vineyards, from the Great Lakes to the Gulf and from the Atlantic to the Rockies is Concord. I wonder how many of those vineyards have conditions suited to the *Labrusca* species of which the Concord is an offspring? This is not treating the Concord on the square, it is not recognizing other species and is doing an injustice to the entire grape industry.

SPRAYING APPLE TREES IN BLOOM.

By W. S. BROCK, *University of Illinois, Champaign, Ill.*

The controversy over spraying plants in bloom, especially apple trees, is nearly as old as spraying itself. Knowing that the development of many insects and fungi is very active just at the time when apple trees are in bloom, together with uncertain weather conditions, many apple orchardists have been and are continually tempted to disregard the bloom as a signal to stop the sprayer. Especially is this true in that section of the Middle West where much of the plantings of apples consists of very large areas under one management. The equipment under such conditions is more often than not inadequate so that it is often quite impossible to spray the entire orchard in the time recommended unless the operator loses no time by reason of accidents to equipment or because of bad weather.

There are of course two considerations of importance in determining the advisability of spraying apple trees in bloom. The first which has received the greatest attention at the hands of fruit growers has to do with the killing of insects which aid in cross-pollination and is foreign to this particular paper. The second consideration is the direct effect of spray mixtures upon the apple flower and the effect of their application at high pressures commonly employed at the present time. It is the purpose of this report to show that none of our common spray materials applied at pressures, not exceeding three hundred pounds, have any deleterious effect upon the bloom, nor cause any appreciable reduction in the quantity of fruit produced.

The data which form the basis of this paper were made in the oldest apple orchard belonging to the University, lying adjacent to the horticultural building. The varieties are Ben Davis, Grimes, Winesap, Whitney, Lady, Westfield, Oldenburg and three or four other little known varieties. The results cover work done during the years of 1916, 1917 and 1918.

THE RESULTS OF SPRAYING IN 1916.

The bloom over the entire block was uniformly heavy in 1916. The orchard was sprayed three times with 8-8-100 Bordeaux as follows: First application when the center bud was just out, the second when the trees were in full bloom, and a third two days later. The material was applied at one hundred and fifty to one hundred and seventy-five pounds pressure, sufficient material being used in each case to thoroughly drench every part of the tree.

No diminution in the set of fruit could be noted since all of the trees which bloomed full set more fruit than they should carry.

THE RESULTS OF SPRAYING IN 1917.

The 1917 work was a duplication of the work of 1916, except that certain varieties received in addition to the three Bordeaux sprays, an application of commercial lime-sulfur diluted 1:20. Two varieties received only the 1:20 lime-sulfur. The effect of the lime-sulfur when used in full bloom was to brown the petals, and to cause some of them to drop prematurely. There was apparently no reduction in the number of fruits set on any of the trees sprayed with Bordeaux, lime-sulfur or combinations of the two.

THE RESULTS OF SPRAYING IN 1918.

Neither Bordeaux nor lime-sulfur was used in the 1918 sprays. The entire block was, however, sprayed once in full bloom with scalecide 1:20, with the exception of two Ben Davis, two Winesap and one Grimes which were sprayed from one side only. The opposite sides of those before mentioned and both sides of all other trees were thoroughly drenched. The results were identical with those of the two preceding seasons.

From observations extending over several years in the orchards of commercial apple growers, it seems to me that there is abundant evidence to show that most certainly no bad effects result from one application of our common spray materials in full bloom. I have repeatedly sprayed Oldenburg in full bloom with both lime-sulfur and Bordeaux. One of our best apple orchardists makes it a practice to spray Rome Beauty in full bloom. Plantings of Ralls which are in full bloom when the calyx spray is applied to Ben Davis and others, have been sprayed year after year with no bad effects. I believe also, that such varieties as Red June, Early Harvest, and Delicious which scab badly would be materially benefited by a good fungicide in full bloom.

SUMMARY.

Apple trees sprayed in full bloom with 8-8-100 Bordeaux, commercial lime-sulfur 1:20, and scalecide 1:20, produced full crops of fruit. There was no apparent injury to the bloom from any of the materials with the exception of lime-sulfur 1:20, which caused some yellowing and premature dropping of the petals.

Observations seem to indicate that an application of a fungicide during full bloom would be advantageous, especially on scab susceptible varieties.

IS FRUIT GROWING A PERMANENT INDUSTRY?

By W. L. HOWARD, *University Farm School, Davis, California.*

In California where large districts of the state are largely devoted to fruit growing, the question has often arisen as to whether the fruit growing industry is a permanent one. A few persons whose opinions and judgment are usually worthy of atten-

tion have stated in my hearing that a district devoted wholly or almost wholly to fruit growing is destined to suffer economic decay in the course of time. Just how long a district can survive with nothing to support it but fruit growing is a matter of conjecture. The arguments advanced as to why fruit growing is not a permanent industry are chiefly based upon the gradual decline of the fertility of the soil. Many of us have been taught that orchards make less demands on the soil than other farm crops, because the trees root deeply and, therefore, take the mineral elements from the soil at greater depths than farm crops usually penetrate. In support of this theory it has been pointed out that virgin forests build up rather than deplete the soil fertility.

Undoubtedly the cultural methods given to the orchard fruits will have a great deal to do with maintaining or depleting the fertility of the soil. For twenty-five or thirty years California orchards have been given clean cultivation annually. In many of these old orchards soil troubles are now developing. In some instances it is only the physical condition of the soil that needs improving. In others, there is an apparent need of increasing the fertility. It should be explained that most of the fruit soils of this state, aside from those in the foothills and mountains, are very deep. The prospective fruit grower here is usually advised against planting fruit trees of any kind unless the soil is at least three feet deep, and that preferably it should be from 6 to 12 feet in depth. As a matter of fact most of the fruit soils of the old established fruit regions are from 6 to 12 feet deep and many of them deeper.

Such soils, by the pioneers were thought to contain an inexhaustible supply of fertility. While experience has shown that even these deep rich soils may eventually show some decline in fertility, they are still, after thirty years or more, continuing to produce orchard crops which are yielding their owners satisfactory returns. There are many soils covered with orchards in some of the more important regions where, after thirty-five years of clean cultivation, the physical condition of the soil is not only very bad but there seems to be a shortage of nitrogen. Of course thirty-five-year-old fruit trees, producing crops annually, cannot be expected to make a very vigorous wood growth, but it is believed that they are not making as much growth as they should, and that the loss of humus and its supply of nitrogen is the cause of the trouble. There is not much question but what long years of clean cultivation have destroyed much of the organic matter in the soil.

Fruit growers are now desperately calling upon the Experiment Station to tell them how to secure a fresh humus supply. Different methods are being tried; the plowing in of green manure crops is perhaps the most general practice. It has not been thought possible to grow summer cover crops in the past, but recently it has been found that certain varieties of beans planted early in the season will make a sufficient growth to shade the ground during

the hottest part of the summer. When such crops can be harvested in a manner so as to permit of plowing under the bean vines, not only is more humus added to the soil than is ever supplied by even the heaviest green manure crops which are grown throughout the winter and plowed under about the first of March, but the nodules from the roots furnish considerable quantities of the much needed nitrogen.

Another plan of improving the soil by shading and also by adding organic matter is through the use of mulches of straw, low-grade alfalfa, stable manure, grass, weeds, or any kind of litter that can be procured for spreading upon the land.

Since most of the fruit growing of California is carried on under arid or semi-arid conditions, the problem of supplying the necessary moisture during the growing season is a very important one. Where the orchard is irrigated two or three times during the summer and cultivated between times, the humus is apparently burned out much quicker than where clean cultivation without irrigation is practiced. It has been found that if an orchard can be heavily mulched with straw or similar material in the early part of the summer, the soil will retain sufficient moisture to carry the trees through, provided the winter rainfall has been as much as 12 or 15 inches. Where the rainfall is less than 12 inches some means would probably have to be found for irrigating at least twice during the year, perhaps in April and in November or December.

Plans have been devised for mulching orchards in such manner that the trees can still be irrigated during the growing season. The principal method used to accomplish this is by means of basins immediately under the trees. The basins are usually shaded by the branches so they do not need to be cultivated after each irrigation. Another plan sometimes resorted to is to sow strips of alfalfa between the tree rows and ridging in such a manner that the trees and the alfalfa may be irrigated independently of each other. In other instances the land is graded into large checks for purposes of irrigating and the whole area seeded to alfalfa. Alfalfa does not seem to injure old orchards, but I have yet to see my first young orchard that was not injured by being planted in an alfalfa field, or by having alfalfa seeded between the rows while the trees were small. Possibly the trouble has been due to too much water for the trees. If the alfalfa is to yield even three or four cuttings of hay, it must be watered at least twice during the season. A heavy irrigation for the benefit of the alfalfa might possibly injure a young tree when it would not hurt an old one. Of course a good deal would depend upon the character of the subsoil. The grower who would try to get five or six cuttings of hay from his orchard alfalfa would be very likely to severely injure his trees by over-watering. Where he is satisfied with two or three crops of hay and is willing to manage the land for the best interests of the trees, and where the alfalfa is not seeded until the trees are in heavy bearing, this kind of intercropping seems to have been a great success and the practice is on the increase. This

manner of handling orchard soil has undoubtedly improved its physical condition and greatly added to its fertility.

In one of the old fruit valleys of this state it is related that the first agriculture of the region was cattle grazing under the old Spanish grants dating back to 1830 or before. The next era was cereal farming, the growing of oats and wheat chiefly. Next came a period of sugar beet growing and this was followed by a few years when beans occupied nearly all of the land. Following the era of bean culture came the growing of apples. About twenty-five years ago this became perhaps the best known apple growing region in the United States. Apples from this center were shipped all over the world wherever fruits of this kind could go. This region was the pioneer one in the use of boxed apples.

During the past five or ten years this once famous region has had more than its share of troubles. While it is possible that the industry will be revived, persons whose opinions and judgment we are bound to respect prophesy that the apple business in the region under discussion will continue to decline and that there is no hope for the district as a fruit region unless a large percentage of the land is devoted to other lines of agriculture, particularly that of stock raising. The reason advanced for this is that only by a diversified agriculture which includes stock growing, can the fertility of the land be maintained.

In support of the belief that the fruit industry in the region under discussion will continue to decline it is cited that the past history of this valley shows that first one and then another line of agriculture was tried and that all of these lines with the exception of the earliest of all, which can not really be considered as farming, did not include stock raising.

Another fruit section of California which is largely devoted to prunes, pears, cherries, apricots, and peaches, and is now perhaps the most consistently prosperous fruit region in the state, is beginning to experience soil troubles. This district has had a history very similar to that of the one discussed in the immediately preceding paragraphs. This region, while growing several different kinds of fruits, has practically no interest in animal production or in the growing of grain crops. It is, therefore, argued by some that this region will eventually decline owing to the inability of the farmers to supply enough organic matter to the soil to build up its physical condition and to restore its fertility. While the fertility is by no means exhausted, there is no question but what the surface soil in many instances is in a very bad physical condition. The trouble here as elsewhere is undoubtedly due to long years of clean cultivation. The orchards here, even those past thirty years of age, are still yielding a good income on a land valuation of \$800 to \$1000 an acre, but the orchardists are fully alive to the possibility that soil conditions may become so bad as to cause serious trouble. They fully realize that the danger is great on account of the high valuation of the land and active measures have been initiated for soil improvement. Many methods are being tried and while all

of them seem to be accomplishing good results, the prophets say the region is bound to fall into economic decay sooner or later because fruit growing in itself is not a permanent industry.

SATURDAY, DECEMBER 28, 1:30 P. M.

The nominating committee submitted two lists of candidates as provided by the constitution and the officers and committeemen as given on page 5 were elected for 1919.

PEACH SYRUP AND MARMALADE.

By C. H. CONNORS, *Experiment Station, New Brunswick, N. J.*

One of the problems of peach growing, especially in districts distant from a local market and in seasons of heavy crops, is the disposal of undersized fruit and fruit which may become too ripe for shipment before it can be picked. The latter condition is likely where there is a labor shortage and has been in evidence during these war years.

When peaches are selling around \$1.25 per crate, it is questionable whether the packing of fruit smaller than a size that would pack 12 peaches to the layer in the tins of the Georgia carrier will pay. The disposal of this portion of the crop in some other method seems advisable.

For several years past, the writer has had this problem in mind. A canning plant would not meet the problem to best advantage. There are a number of community canning plants, but the material that they would handle on a commercial scale would not quite meet the conditions outlined, as the small fruit would not make a first-class pack and the over-ripe fruit could not be packed satisfactorily.

If the bulk of this waste fruit could be considerably reduced and then preserved the conditions desired would be met. With these facts in mind, the Horticultural Department of the New Jersey Experiment Station in the spring of 1918 gave its consideration to the installation of a plant that would turn such fruit into syrups and marmalades. A plant was to be installed that was designed to handle the discarded fruit from one large orchard or that might serve a community of several small growers.

The time was unpropitious. The high cost of material and bad shipping conditions made the cost of installation high. The failure of the crop in the northern peach growing sections made the season one of high prices and almost any grade of fruit sold to good advantage. However, funds became available and the plant was installed.

The equipment consisted of a 3 horse-power steam boiler, two small retorts, a scalding basket, two dipping baskets, a crane

and one 28 gallon enamel lined steam-jacket kettle. The cost for these was \$516.80. Various other items, such as pails, pans, knives, tables, shelter for boiler, etc., brought the cost up to about \$700.00. The boiler was much larger in capacity than was required for the operation of the plant, but was so purchased with the idea of using it for boiling lime-sulfur mixture for the winter spray.

The product was to be packed in 8 ounce and 16 ounce round screw cap jars. These cost \$12.00 and \$17.63 per gross, respectively.

The operation of the plant during the first year, because of labor conditions, the high price the fruit was bringing in the market, and the necessity for developing recipes, was limited to an experimental character. Various varieties were used in comparison to determine the possible amount of variation in the product.

In the preparation of the syrup, the fruit was allowed to ripen on the trees to get the maximum flavor and sugar content. The fruit was washed and then "quashed" in the hand to break the skin. It was then cooked until the pulp was quite soft, requiring about three hours. It was then strained through cotton flannel and allowed to drip for several hours. The resulting syrup was then measured and the sugar added.

It was found that the amount of sugar required to give the necessary sweetness was much less than that recommended in household recipes, so sugar was added in the proportion of 1 to 3. Here one fact was discovered. The second cooking had to be extended over a considerable period in order to make a thick syrup, and in consequence part of the sugar probably reverted and specks of carbon appeared in the syrup and it became darkened in color, losing the individuality in color and flavor that might be expected from different varieties.

The quantity of syrup obtained from the different varieties was rather uniform for varieties that ripened at about the same time. Carman and Slappy yielded in the neighborhood of 90 ounces of syrup to the basket. Carman gave a syrup that was clear and reddish in color. The others were rather nondescript.

The marmalade required somewhat more labor. The fruit was allowed to become fully ripe on the tree, and as soon after picking as possible was scalded, peeled and cut up, the stones being removed. The material was then cooked for about two hours, strained through cheese cloth and the liquid portion boiled down. Then the solid portion was added together with the sugar in the proportion of 1 to 6 and the product cooked for about an hour. This quantity of sugar was sufficient to give a good flavor, but was not enough to act as a preservative. Dependence was placed upon the jars. These were the round type with an aluminum screw cap lined with cork. After being packed they were sterilized at 15 pounds for thirty minutes. The cork lining was very poor. If the cap was screwed down too tight the threads were strained, and

there was not enough sugar to act as a preservative. Hence, there was considerable spoilage by mold and a few even had fermented when examined about two months later.

A basket of fruit naturally made more marmalade than it did syrup. Of the early varieties used, Carmen and Slappy yielded about 185 ounces per basket, Early Crawford 140 ounces, and Hiley, Belle, Elberta and Stump about 110 to 120 ounces of marmalade to the basket. This variation in the amount of product from the different varieties is probably due partly to moisture conditions, as the later varieties had to obtain their growth during a period of drought.

More individuality was shown in the marmalade derived from different varieties than was the case with the syrup. Yellow varieties made a yellow marmalade and the white varieties a white or pink or red marmalade. There was individuality also in the flavors. The varieties of the Crawford type gave a somewhat better flavor than Elberta and Slappy.

Owing to the relative smallness of the output and the amount of spoilage, no attempt was made to market the product. Several lessons were learned, however. The bulk of the product can best be handled by two classes, confectioners and restaurants. The plan for next year is to limit the sizes of the packages to two or three. The first size will be two-ounce. The style of jar is still to be selected, but will probably be a glass topped sealed jar. This size, designed for restaurants, will be called the individual size and will give a sufficient quantity for an individual portion to be served with hot cakes, waffles, etc. The other size will be one or two quart glass topped jars. By using only these two sizes, the expense of shipping cases will be largely eliminated.

A distinctive label has been prepared which will bear the same seal that is upon our peach crate label, and our endeavor will be to keep the quality of the by-product on a par with the quality of the fruit that we ship.

The lessons learned during the first season of operation pertain, first, to the type of package to be used, second, to the addition of more sugar to the syrup and marmalade so as to obtain more bulk from the fruit used, and third, to the necessity of at least one more cooker of the same capacity as the one already installed or even larger. The possibility of adding a small quantity of a green fruit high in pectin (such as gooseberries were formerly used in making cranberry jam) that would not injure the flavor of the product, but would tend to slightly thicken it, is being considered.

The utilization of waste in some by-product often means the success or failure of a commercial enterprise. It is believed that peach-growing can be made more profitable by using in this manner the carloads of fruit that go to waste in a season of big crops and small prices. We hope that this demonstration experiment will assist in the conservation of food, and in making peach growing more profitable.

VEGETABLE SEED GROWING AND BREEDING.

By J. W. CROW, *Agricultural College, Guelph, Ontario, Canada.*

The very modest amount of vegetable seed work I have done was undertaken, first, to find out whether high-grade seeds could be grown in Canada, and, second, to improve existing stocks. It was felt that if growers were to be asked to undertake commercial production of seed crops it would be to the advantage of all concerned if they could have placed in their hands well-bred, high-class "stock" seed with which to begin. We made a start with Paris Golden Self-Blanching celery in 1913 and our home-grown product surprised us in 1914 by its excellence. In 1915 we made a beginning with Detroit Dark Red beet, Chantenay carrot, Glory of Enkhuizen cabbage, Southport Yellow Globe onion and Golden Bantam corn, and we have since added Hollow Crown parsnip, Victoria spinach, also beans of several varieties and Wayahead and Grand Rapids lettuce. Of the last named we were fortunate in securing from Mr. D. N. Shoemaker, of the United States Department of Agriculture, some of his best seed which we have continued to grow and which is rated by all of our growers who have tried it as the best they have ever seen. The calamitous frost of September 9, 1917, wiped out our three years' work on corn and we have not started again.

We find that the problem of purifying varieties and strains is much more difficult than we had supposed so that after four years of painstaking work we find ourselves possessed of but limited quantities of our best stocks. It must be borne in mind that our work has not been done on a large scale because of limited opportunity and because the accuracy of detail involved has precluded larger scale operations. We have learned some things of interest and importance, nevertheless, and I am pleased indeed to pass on to you such information as we now have.

We have learned that many, perhaps most, of our vegetable varieties are far from pure and are much in need of attention on the part of careful breeders. For example, in Southport Yellow Globe onion we find this year in some strains a percentage of white bulbs. These are grown from the second generation of our own seed and we know positively that the parent and grandparent bulbs were Southports of the very best type and color. We know, too, that no onions of any other color or kind have been grown anywhere near and that no out-crossing has occurred. The only explanation is that the white color (which occasionally shows up in any strain of Southport) has not yet been bred out. In all our work we harvest the seed of individual plants *separately* and *test out their progeny in separate lots*. Some single-plant progeny lots show no white, but certain others show as high as two or three per cent. In our onion breeding work this year we sowed the seed in flats indoors and transplanted carefully by hand so as to get every seedling that could be induced to grow.

We have learned that high-grade seed of good germinating power can be produced at home and in our commercial truck garden this year all, or nearly all, of our beets, onions, celery, cabbage, spinach and lettuce were grown from our own seed. Parsnip and carrot seed of our own growing made a good showing this year in comparison with commercial stocks, and seed of these crops produced this year will be used for next season's main crop.

Our experience with lettuce and cabbage has not been satisfactory and I question whether these seeds can be grown in a commercial way in our climate. The heat of summer and the rains we commonly get in the blooming season seem to prevent free setting of seed. We have also tried cauliflower, but with even poorer results, although it, no doubt, could be produced under glass by starting the plants in time to get them in bloom early in June. We have grown cabbage seed under glass in a small way with excellent results.

With celery we have succeeded admirably by storing the selected plants until January and then planting in the greenhouse bed three feet apart. We have grown our own celery seed for five years and in that time have had only one failure. This was our own fault and could easily have been prevented. Individual plants have yielded as high as ten ounces of seed and our average for the four successful years is around 5 ounces per plant. At this rate it would pay to grow celery seed as a glasshouse crop if one could work up a market for a strictly high-class strain. This should not be difficult as celery specialists do not grudge the extra price if the quality is there. We have developed three strains of Paris Golden of considerable promise and last spring sent out a number of samples for testing.

Our experience with onion, beet and spinach for seed has been satisfactory and has quite convinced us that these seed crops could if necessary be produced in our own province in sufficient quantity to more than supply our own needs. It is probably true that some of the western mountain valleys with dry summer climates could grow these seeds cheaper than they could be grown in Ontario, but it is, nevertheless, some satisfaction to know that they can be grown in this province sufficiently well to justify commercial growers taking them up as a business venture. Some of our own carrot seed has germinated satisfactorily, but some has done very badly and we do not yet know whether this can be overcome. In the case of parsnip, the web worm has been with us an insuperable obstacle and while this year we secured a fair yield of seed the cost of combatting the pest was out of all reason in a business way. At other points in the province it has been much less injurious.

It has been frequently alleged that home-grown seed is necessarily inferior, but so far as our experience has gone we have found no justification for the statement, provided care is exercised in selecting seed plants or in roguing out undesirable types. In fact it would appear as though seed stocks bred and raised at home

would likely prove even more satisfactory than those raised elsewhere. Both the science and practice of breeding seem to point in this direction and even if the stock seed we are producing is ultimately sent elsewhere for commercial increase it would seem reasonable to say that the preliminary breeding work and the isolation of desirable strains should be carried on in the region where the resultant commercial crop is to be grown. At any rate, there is certainly no doubt in my mind concerning the possibility and practicability of improving vegetable crops by breeding. It is in this connection that I wish to point out our most important discovery, which is not a discovery at all, but simply corroboration of what breeders have long known, viz., the importance of pedigree. As already stated, our invariable practice in breeding for improvement is to save the seed of each parent plant *separately* and to sow it *separately*. The individuality of each resulting progeny lot is always obvious and frequently very marked.

Most of these plants cross-pollinize more or less in nature and up to the present we have taken no steps to prevent this because of the difficulty of so doing and because breeders have so often warned against the dangers of too close breeding. We have some evidence, however, to suggest that possibly more rapid progress would be made if self-fertilization were practiced in those plants which normally cross and in which selfing is possible.

The basis of all improvement lies in the fact that two individuals which look alike may vary greatly in the ability to transmit their good points to their offspring. By testing their breeding power we are able to discard all poor stocks and retain those of high breeding value. We have found that it is not possible to know beforehand how a given individual will behave in respect to transmitting its characters—the only means of knowing is to try it and see.

As to whether vegetable growers could grow their own seed supplies with profit, I am inclined to think it would not pay ordinary growers except in case of crops like tomato, where it is easy to mark selected plants and leave the whole crop for seed. In general it is perhaps safe to say that no one but a specialist would care to go to the trouble of making single-plant progeny tests and unless this were done one might better buy seed from a good commercial seed grower. There is no question in my mind but that it would pay a grower of a specialty crop to grow his own seed, but the point may well be emphasized that the important thing after all is the breeding of it. It is a simple matter to grow seed, but it is not a simple matter to produce seed which will give a strictly high-class, uniform crop of the kind that will increase the grower's returns by 10 or 15 or 25 per cent.

We have found that by far the most difficult part of seed growing is the proper drying and curing of the seed. The seed heads of carrot, parsnip and onion are picked as they ripen. They require to be spread out under cover in a dry airy place to cure.

The practice with beets is usually to cut the whole plant when the seed begins to shell. The same is true of lettuce, spinach and celery. If curing can take place under cover one should have no difficulty whatever, but if the curing must be done outdoors look out for trouble. Our practice has been to use greenhouses and cold frames for curing seeds, but an open, airy shed would be satisfactory. The point to be guarded against is wet, which delays ripening and causes mould and premature germination besides actual loss from shelling. In using glass one should see that the temperature does not run too high as the soft and immature seed would probably be injured thereby.

In handling beets, carrots and parsnips for seed, select smooth specimens of medium size or larger, keeping close to variety type. Store in pits or in a cool cellar. Do not allow the roots to wilt or even to become dry. The best plan is to store in earth, which should be always moist. Set out in well-prepared land early in spring. Plant firmly, covering crowns not more than one-half to one inch deep. Our practice is to plant in plow furrows. Long roots like parsnips can be laid in on a slant. Space the rows three feet part, with the roots two feet apart in the row. In small scale work support the plants to prevent damage by wind or rain. In large scale operations this is not possible and hilling up is an advantage. Tillage should be thorough and frequent, as seed plants seem to suffer very quickly for lack of moisture. The seed ripens in August and when thoroughly dried may be thrashed by rubbing between the hands or with a flail. Beet seed may be put through an ordinary thrashing machine with half the teeth off the cylinder. Cleaning may be done with an ordinary fanning mill, although it is only fair to say at this point that if seed is to be handled in quantity special machinery will be required for thrashing and cleaning.

In commercial seed growing practice it is the custom with root crops to make late sowings in order to produce small roots which will require less space in storage. These small roots are called "stecklings" and while the commercial seed grower is compelled to use them in order to save space it is probable that the best results in breeding would be secured by using well-developed roots of not less than medium size.

Onions intended for seed growing should be stored in a cool, well ventilated, dry room. Bulbs selected for planting should be firm, with small necks and should represent the proper type for the variety, with the exception that globe varieties have a strong tendency to produce flat-bottomed stock and the ideal seed type in a globe onion is, therefore, slightly longer at the base than would be desired for exhibition. Some of the best commercial growers of onion seed recommend early fall planting, setting the bulbs in well-drained land three or four inches deep. If spring planting is followed they should be set as soon as the land is ready to work. Space the rows three feet apart with bulbs twelve inches apart in

the row. It is advisable to plant deep and hill up so as to support the seed stalks. Seed ripens in September and after curing and cleaning the good seed may be separated from the poor seed by placing it in water. The good seed goes to the bottom and any which floats can be discarded as worthless.

In our climate spinach will not winter *outdoors*, but we have no trouble in getting a good crop of seed from the first sowing made in the early spring. We have been breeding spinach for long standing rather than for earliness and our practice is to thin the plants to a foot apart while they are still small and rogue out those which start to go to seed too early. The spinach plant is dioecious and thus only about one-half of the plants produce seed. The others produce pollen only and are necessary to the fertilization of the seed-bearing plants.

Lettuce is handled in practically the same manner as spinach and while I have intimated in the foregoing that we have not been altogether successful in getting a satisfactory yield of lettuce seed, I may state here that there is probably no plant which will show so plainly the effect of careful breeding methods. Lettuce is entirely self-fertilized and single-plant progeny lots show remarkable individuality.

Land for seed growing should be in good tilth but should not be too heavily supplied with nitrogenous manure. Superphosphate should be used in abundance and three hundred to four hundred pounds per acre would probably not be too much.

I have not mentioned saving seed of tomato, sweet corn, cucumbers or melons, for the reason that many growers already save their own and with excellent results. We are doing some work with garden varieties of beans and the indications are that it would pay well to grow a special block of one's favorite commercial variety and rogue out carefully all plants of undesirable types or those which show disease. The bean plant is subject to a long list of diseases and I am hoping that by careful selection of seed plants, followed by the testing of the same after the progeny lot method, it will be possible to develop satisfactory varieties free from disease.

We have had under way for some years the breeding of outdoor tomatoes and glasshouse cucumbers and hope to have some valuable new sorts to send out for testing at an early date.

In conclusion, it should be pointed out that the seed situation is in a very unsettled condition at present. While the war was in progress we were compelled to undertake the growing of our own seeds in order to insure a supply. Now that hostilities have ceased and traffic is likely soon to return to normal, we are all keenly interested in learning whether there are surplus stocks of seed anywhere and in what direction they are likely to move. During the war considerable quantities of seed were exported from the United States to Europe and both the United States and Canada were well on the way toward producing all of their own requirements. It is altogether probable that since we have had to learn how to grow

seeds we shall continue to grow them. Whatever may be the outcome with regard to the readjustment of the world trade in vegetable seeds, I incline personally to the view already expressed that the grower of a specialty crop would find it profitable to produce his own supply of well-bred seed. Especially is this true with the higher priced crops or those in which market value is based on the finer points of color, form, or quality, rather on that of quantity alone.

VEGETABLE GARDENING ON A WAR BASIS IN THE COLLEGES AND STATIONS.

By C. E. MYERS, *Experiment Station, State College, Pa.*

When this subject was suggested for discussion at the annual meeting of this Society, the second battle of the Marne had not been fought. The cause of democracy was in the balance and every effort was being put forth which might possibly contribute to the turning of the tide. Industries and business of all kinds were being reorganized and readjusted to make them more efficient and to aid in bringing about the one great end—the winning of the war.

Almost from the time that hostilities began we were told that "food will win the war;" yet so great was the demand for the production of munitions and the need of men for the army, that unless a person was actually engaged in tilling the soil and producing crops, he was, in some instances, given to understand that his efforts as a horticultural worker, either as a teacher, or an investigator, were not the kind that was needed in the present emergency. Some of the younger men of the profession were with difficulty retained in their positions because of the point of view taken by some of the draft boards.

While no one familiar with the far reaching results of the work in horticulture would question its direct contribution in the present emergency, yet it was thought that a conference of the men engaged in the work would prove profitable. At this conference past experiences could be related, points of view exchanged, and perhaps a more definite plan of work outlined for the future.

Since then the war has been won, and instead of formulating plans which would be especially applicable to war-time conditions, we shall enumerate some of the things which the various colleges and stations have done, quite independently, but none the less effectively.

Unfortunately our record of achievement is incomplete. For a long while after the subject was suggested there was considerable uncertainty as to whether our meeting would be held, and there were also other delays, so that nothing was done to secure data until less than three weeks ago when a questionnaire was sent out to the institutions where it was believed that the industry had most probably received especial attention. Of the thirty-seven

inquiries thus sent, thirty replies were received, and the cooperation thus afforded has been very gratifying.

It is impracticable to include in this paper a complete record of the work that each institution has accomplished, but if you will go with me for a few minutes we will make a flight by airplane, in fancy, from the granite cliffs of New Hampshire to the Golden Gate, with a few stops along the way for gasoline and oil, when we shall note some of the more outstanding features of the work accomplished at the various places.

At the New Hampshire College, special courses were given to girls in vegetable gardening, while the men were trained to fill positions as garden supervisors for cities, towns, schools and factories. The head of the Department of Horticulture was made supervisor of war gardens, and the assistant professor of horticulture spent a considerable part of his time in stimulating war garden activities throughout the state.

At Massachusetts the commercial phase of the work received especial emphasis. Growers were urged to produce staple crops in abundance, and also produce more of their own seed. Two men in the department devoted almost their entire time to home gardening work, with very marked results. It is estimated that about 24,000 acres of land were planted in strictly war gardens, and the value of the crop was estimated at \$6,000,000.00. This was the result of the combined activities of the college, county agents, state food production committee, and the national war garden movement. In the market gardening field station demonstrations were carried on in vegetable seed production. A number of publications were also issued for the further stimulation of the vegetable production movement. "A fact that should be noted is that many of the leading vegetable growers of Massachusetts were chairman of the food production committees in their local towns, and lent their time and energy and knowledge without stint in the face of the very apparent fact that the home gardening would work considerable hardship to them."

The work at the New Haven Station was somewhat handicapped in the change of personnel in those engaged in vegetable gardening work. However, one project, which was of direct connection with the food production, was a test of four varieties of sweet potatoes and eight of beans, including two of western origin supposed to thrive on dry soil. These were planted in sandy land that is very common within the limits of the city of New Haven, and is also represented by large areas of land north of the city. The person in charge of vegetable gardening was also the secretary of the Connecticut Vegetable Growers Association, and spent a great deal of time in the affairs of the Association, and also in the war gardening work in the City of New Haven.

At Cornell the chief line of activities was with respect to school gardens. It is estimated that there were 170,000 home gardens; 17,000 school gardens; and from 10,000 to 15,000 factory gardens in the cities and towns with which the extension man car-

ried on his work. In the instructional work at the college there was considerable emphasis laid on the emergency with reference to food production, and courses were given to teachers and garden supervisors which would aid them in carrying on the general food production campaign. All of the extension and teaching work was based upon results of previous investigations in vegetable gardening.

In Pennsylvania, attention was directed chiefly along the promotion of the war garden movement. One man gave his entire time to this work, and a bulletin of an issue of 100,000 copies was distributed. Special sources were given to prepare supervisors for war gardens. A project with respect to fertilization of vegetables was planned and preparation made to institute it in one or more of the leading trucking districts of the state.

At the New Jersey Experiment Station special efforts were made to secure an increase in the tomato and sweet potato crops. It is estimated that the increase in the tomato production in southern New Jersey was about 50,000 tons over that of last year and there was also an approximate increase of 300,000 bushel of sweet potatoes in the same section of the state. This increase is attributed to the combined efforts of the county agents and extension specialists. It was through the activities of these agencies that a more equitable price for canhouse tomatoes was secured for the growers. In the College, special attention was given to the training of men for war garden work.

At Delaware the principal war work was conducted with tomatoes and sweet potatoes. The tomato work was based on experiments in transplanting plants, but because the ideas involved were new to the growers, not much progress was made. However, with sweet potatoes the results were much more encouraging. Two or three years previous to the war, quite extensive investigations were carried on in growing sweet potatoes with the use of barnyard manure and discarded manure from mushroom houses, which showed that good yields could be obtained with the addition of but a small amount of commercial fertilizer. It was found in an experiment that potash is a vital factor in growing sweet potatoes, and as soon as potash became scarce the growers were in a very uncertain position. However, by making use of the results of the investigations previously noted, and as a result of advocating these manures, the sweet potato crop was actually increased during the last year, and it is believed that more was accomplished because of the emergency which existed than would have been possible to accomplish in ten years under normal conditions.

At the Maryland Station, it was considered inadvisable to plan projects because of the time necessarily involved, but the demonstration work was based upon results already obtained. Some of the men temporarily discontinued their scientific investigations and devoted their time exclusively to the war garden movement.

At the Virginia College and Station, one man gave his entire attention to propaganda work in reference to home and commercial gardens.

The Truck Experiment Station at Norfolk contributed materially to the promotion of the home garden movement, as well as commercial vegetable gardening, by the use of the results obtained in investigations for the past several years with respect to varieties grown, fertilizer treatments for the crops, and the control of vegetable diseases and insects.

At the North Carolina institution, although no new projects were started solely and specifically for war purposes, every one interested in the work bent all the energy at his command to the winning of the war, and through bulletins, lectures, extension workers and county agents in every county sent broadcast throughout the state the knowledge which has resulted in the greatest production the state has ever known. All-the-year-round-gardens" was made a special feature in this state.

In Georgia, the work was chiefly along extension lines, the teaching being based upon results previously obtained from the work at the experiment station.

In Louisiana, difficulties were experienced in the changes of personnel and inability to fill positions. Some work was done with sweet potato storage. As in other states, the war garden movement received a great deal of attention. One person gave her entire time to the stimulation of this work, in which more than 20,000 gardens were reached. In addition to this many circulars to meet special conditions were published and disseminated.

The West Virginia institution concentrated chiefly on the extension phase of the subject and gave special attention to the production of the potato. One man gave his entire time to the development of the potato industry. The war garden work, however, was not overlooked, although the department was unable to obtain a suitable leader, and in lieu of this, the whole department turned in and did everything in its power to stimulate the city and miner's gardening movement. A survey during August indicated that this program added one and one-half million dollars worth of produce.

At the Ohio State University most of the work having to do with war garden problems in vegetable gardening was of an extension character. Several bulletins were issued to the extent of many thousand copies. Through the extension department there were projects carried on such as tomato spraying and potato spraying, and potato seed selection which no doubt helped to increase the yield of these crops. The services of the entire staff of the department of horticulture were available for such information as might be desired.

The Experiment Station at Wooster published a great deal in the way of instruction, and has furnished a large quantity of gardening material for the newspapers and through the monthly bulletins. The greater part of the articles prepared for instruction

were based upon results of the experimental work and of well-known horticultural facts.

The Department of Horticulture at Purdue University gave a large amount of time and effort to war gardening. Particular attention was devoted to the potato work where it has assisted in securing and urging the use of better seed stock. The department also cooperated with the state and national seed stocks committees in locating the needs for their supply of vegetable seeds. Material aid was also rendered the canners of the state in stimulating an increase in acreage and production on the part of the growers. Special courses were given at the University in training garden supervisors and a course of lectures, which was attended by from 30 to 60 teachers, was given in the City of Indianapolis. Two bulletins on vegetable gardening were issued by the Experiment Station.

In Illinois it was felt that the war gardening movement was an important factor in winning the war, since it lead thousands of people, who never thought of gardening before, to furnish vegetables for their own tables. This has resulted in the release of large quantities of food for foreign consumption. The war gardening movement in Illinois was stimulated by the Department of Horticulture in that many of its leaders were secured from its graduates in horticulture. The Station also published three circulars on gardening subjects to meet special demands. In addition to these publications issued by the Experiment Station, members of the staff furnished manuscript for three circulars on vegetable gardening published by the State Council of Defense for use in the Boys' Working Reserve, and also manuscript for a publication entitled "The War Garden," issued by the War Committee of the University of Illinois. When urgent demands came for increasing the number of county farm advisers in Illinois as an emergency war measure, the department released one of its most valuable vegetable men to take up the work in a section where vegetable interests were especially important. The vegetable division also contributed one vegetable man for work in France.

In Michigan unusual efforts were made to encourage war gardens. Extra men were employed and all contributed to the stimulation of the work as much as possible.

In Wisconsin it was felt that it was doubtful if there was ever a greater proportionate increase in any line of food production during the war than there was in gardening. There was more written on the subject and more people who went into it, particularly from the home garden standpoint than there was in any other line of food industry. As a result of the various activities to promote an increase in the work in vegetable gardening, it has been estimated that the increase in acreage was possibly 150 to 200 per cent over what there was previous to the war. Special attention was given to providing instruction for beginners in gardening. Circulars and bulletins were issued and lectures given in cooperation with the State Horticultural Society in all the larger towns and

cities of the state. In the regular college work special gardening courses were provided, the object being to instruct students to supervise and organize garden work in their own communities.

Minnesota directed most of its attention to the stimulation of war garden movement. One man gave almost his entire time to the work, and another had charge of the boys' and girls' club work, who reports that there were about 20,000 boys and girls enrolled in gardening in the state during the past year. It is estimated that the value of the production in the home gardens exceeded \$4,000,000.00. With respect to the Experiment Station work and the outgrowth of its direct use important results were obtained in the selection of seed potatoes. The dissemination of this information resulted in the saving of vast quantities of seed and increased the production of the crops.

At North Dakota, most of the work in vegetable gardening towards winning the war was done through its Department of Extension which organized boys' and girls' clubs. One hundred and eighty-two clubs were organized with a total enrollment of 3,472. Out of these, 1,434 reported at the end of the season. The size of the plot required by each member was one square rod. It is estimated that \$16,600.00 worth of vegetables were produced at a cost of \$7,000.00. In addition to these clubs, there were some 1,300 boys' and girls' war gardens producing food having a value of \$13,900.00.

At Missouri a model home garden was instituted as a war-time project. A great deal of attention was given to the promotion of vegetable gardening in boys' and girls' gardening clubs which numbered 8,000 members in 1918. Specialists were also sent to some of the large towns for work, especially with adult gardeners.

In Kansas timely circulars were published by the department and sent to every county agent, farm bureau and rural school in the state. Competent speakers visited the principal cities and towns, and assisted in the organizing of garden clubs. Emergency agents were sent to the principal gardening sections after being given a special course by the Department of Horticulture. The information sent broadcast through the state was compiled through experiments in vegetable gardening, which have covered a period of twenty years. This related to the best varieties to grow, the proper preparation of the soil, fertilization, and control of insects and diseases. Rather extensive reports received from men in the field indicated that the areas devoted to gardening were increased at least 200 per cent.

At Iowa special attention was given to the following projects as war activities in the vegetable gardening work, production of shell beans, production of sorghum syrup, canning of vegetables, drying of vegetables, and war gardens. The statement is made that it is doubtful if there has been any line of production in the middle west where there has been any greater activity during the period of the war than in the vegetable work.

In Nebraska the chief items of interest resulting from wartime conditions were the elimination of many variety tests and the growing of a few on a commercial scale so that the ground would be made productive and the records of commercial importance. The second was the forcing of a grading scale upon the potato growers of the country, which met with a good deal of opposition at first, but which seems to be a decided advantage and has convinced the growers that it is profitable to grade for the markets. The war garden movement also received a great deal of attention and was of value not only because of the large amount of produce raised, but also was of great educational value to the people. An irrigation project was instituted and demonstrated that the yield could be more than doubled in certain crops by the use of water supplied at the proper time.

In Oregon the educational phase of the subject received a great deal of attention. Meetings were held for the purpose of interesting farmers in the contract production of vegetables for canning and dehydration plants which received large government orders. Many of these farmers had not produced these crops previous to this time and instructional material from the college was used as an aid in their work. Demonstration trains were run to various parts of the state. One of these trains was devoted to the question of home production of vegetables. A regular course in vegetable growing was given at one of the large department stores in Portland. Vegetable gardening extension work in the interests of vegetable production was covered also by the four-minute-men. These united efforts brought about an unparalleled production of vegetables both in a contract way by farmers for the processing plants and also by city dwellers. It is estimated that the amount of produce which has been processed during the year will amount to between thirty-five and fifty million dollars, which includes both fruit and vegetables. The instructional work in the courses was largely changed with the view of training men for quartermaster's work in purchasing, inspection and distribution of horticultural goods.

In California the work was severely handicapped because of so many men joining the Service. Nevertheless the division published during the period of the war, eight circulars relative to various phases of home and commercial vegetable gardening. aside from this it has taken over the planning and somewhat of the detailed work of preparing and of planting from 500 to 1,000 acres in vegetables, which are being dried for government use in Europe.

While this report is necessarily brief and incomplete, yet in our opinion, it serves to show that the persons engaged in horticulture as a profession, have not failed to apply their knowledge and energy to good effect in a thoroughly practical manner, and have thus contributed materially to the winning of the war.

REPORT OF THE COMMITTEE ON GRADUATE WORK.

By W. H. CHANDLER, *Cornell University, Ithaca, N. Y.*

Since such thorough reports have been made by this committee on previous years, it does not seem wise to consume much of the time of the Society with discussions of graduate work. The essentials for good graduate work are equipment, a good library, and teachers with sufficient scholarly attainments to direct the work. It does not seem then that graduate work in pomology can be greatly improved through discussions in this Society, since scholarly attainments cannot be acquired through resolutions by a society. The purpose of graduate work for the student is to assist him in acquiring the ability to arrive at the truth through a careful weighing of the evidence. In agriculture the evidence to be considered may be placed roughly in three classes. Since our knowledge of the underlying principles is so limited, it is evident that no sound judgments can be reached without a knowledge of the actual experiences and practices of growers. The practices of the growers represent the accumulated experience of very many men, and the man is wise who gives them very careful consideration before reaching the conclusion that some different practice would be better.

Of course the kind of evidence most commonly considered is that secured through field experiments. In our work, however, the errors involved in such experiments are so exceptionally large that the results must be accepted only after the most careful consideration.

The third kind of evidence is that of the underlying scientific principles. Since our knowledge concerning such principles is so incomplete, we can rather seldom reach conclusions as to desirable practices merely by reasoning from these principles. Our conclusions will certainly be more nearly true, however, if a broad knowledge of scientific principles is brought to bear in valuing the evidence presented by practical experience and field experiments. Further, the best scientific habits of thinking have been developed by the workers in these fundamental sciences. For that reason alone the graduate student should become acquainted with the results and methods of some of these sciences.

Naturally, students presenting themselves for graduate work will have had different amounts of training in these three different essentials. Thus a man may have done enough research work that he has acquired the scientific point of view, but he may wish to broaden his grasp of the fundamental sciences into which his work leads. Further, of course no two graduate students are likely to have the same plans for the future. For these reasons the work required of graduate students should not be the same for all. A graduate school, then, above all institutions, should be encumbered by very few rules or iron-clad requirements.

While committee reports on methods of graduate work, then, do not seem desirable, it does seem desirable here to emphasize the need of graduate training for a particular group of workers. Everyone seems to recognize the value of such training for the teacher and investigator, but its importance for extension workers does not seem to be so generally accepted. Yet it seems to me that it is fair to say that the questions of the extension man, considering the way in which they present themselves, are more difficult than those of any other worker and require, in addition to close practical touch, a broader background of fundamental knowledge for their answer than those of any other workers. The teacher is dealing with men who who are separated, temporarily at least, from the difficult questions that are constantly presenting themselves in practice. Further, he outlines the course, and determines pretty largely the nature of the problems to be discussed. He has time, in advance of that presentation, to inform himself concerning their possible solutions, and as a last resort, so far as his own personal interest is concerned, he may hide his ignorance behind his interest in athletics. The investigator may choose problems suitable to his training and intellect, and a man of very mediocre training, but with sufficient patience, and abundance of time for deliberation, may make useful discoveries. The extension man, however, has no such choice as to the questions to which he must give attention, but generally has them thrust at him without the slightest opportunity for preparation. If he is attempting to be of any assistance to the better growers, he is dealing with a class of men who will be quick to detect his errors, even though they may like him because of his personality. Yet it seems to me that if the extension work is to have permanent value, the extension man must be one whose training enables him to be of assistance to the better growers. In any community containing aggressive, successful growers, the man who is unsuccessful it seems likely will not be so through lack of information. He is more liable to be so through some deficiency of character, assuming that he has the necessary capital and a satisfactory location. None of these last items can be supplied by the most optimistic extension worker. In any given community, then, the measure of an extension man's service will be the amount of assistance he can give to the best growers, who are examples for the others. It may be said that there are whole communities which are backward and may be assisted by a person thoroughly familiar with the experience of other sections that are more progressive. At the outset, however, the worker in such a community is confronted with an exceptionally difficult problem that requires not only a broad fund of knowledge, but exceptionally good habits of thinking, in determining whether or not it would be wise to foster an industry in a section where it has not yet been demonstrated by experience that such an industry would be profitable.

Some will say that it is the function of the extension worker to deal not with problems at all, but only with known facts, the difficult problems being left to the research man, who must furnish the background for the extension worker. Of course anyone who has taken the trouble to observe the methods of research knows that in any research of value the worker must follow his own leads, whether they go in the same direction that the extension questions point or not. The questions in mind in the above discussion are those of a temporary nature, the answers to which are often available now through a comprehensive use of our present fund of knowledge. Anyway, what man of ambition and initiative will want to turn everything that is not superficial over to someone else? Further, a man without broad fundamental training may not be depended upon to know when a question is too deep for him. The answer to a question may seem simple merely because he is not acquainted with its complications. He may thus do great harm by being too easily satisfied as to the true answer to a question.

In the rapid development of extension, I think we have been justified in choosing men whose personality and knowledge of practical details would fit them for amicable dealings with the growers, even though their training might not be of the best. Yet it would seem that now they should be encouraged and given opportunity to secure the best possible fundamental training to supplement their knowledge of practice. Not only will their value to the states be greater, but from the standpoint of their own interest it seems to me that it is only through such training as will put them in touch with the methods and findings of science that their work will have sustaining interest.

It is hoped that nothing said above can by any possibility be construed as a criticism of extension workers. It has been the purpose decidedly to oppose the view that their work is more superficial than that of others. It seems beyond question that their work requires the maximum of scientific insight, and extension work can have sustained interest to original and thoughtful men only when this fact is realized and acted upon.

REPORT OF COMMITTEE ON UNDERGRADUATE WORK.

By J. W. LLOYD, *University of Illinois, Champaign, Ill.*

The recent withdrawal of the chairman and one other member of the committee has made necessary the appointment of two new members at so late a date that there has been little opportunity for organized work on the part of the present committee. Under the circumstances, it has been thought best that each member of the committee present a brief report on some phase of the work, and that no attempt be made to prepare a composite report from the committee as a whole. I shall speak briefly regarding certain matters pertaining to the work in vegetable gardening.

A perusal of the catalogs and announcements of a number of agricultural colleges indicates that there are three courses in vege-

table gardening quite generally offered by such institutions in the United States. These are (1) a general elementary course, (2) a course in the growing of vegetables under glass, and (3) an advanced course in market gardening, emphasizing the commercial viewpoint. Some institutions offer various other courses. These include Systematic Vegetable Crops, Truck Farming, School Gardening, Vegetable Judging, canning, Literature of Vegetable Culture, and Experimental Vegetable Culture.

Of these supplemental courses, the one which is apparently receiving attention from the largest number of institutions is that in Systematic Vegetable Crops or Systematic Olericulture. The committee wishes to emphasize the importance of a course of this kind for students specializing in vegetable gardening. The three courses most commonly given deal primarily with methods of growing the crops, rather than a study of the plants themselves. But a student of vegetable gardening should know more than cultural requirements. Intimate familiarity with the gross and even minute morphology of the various plants must precede any intelligent attempt at plant improvement. Differences in type must readily be recognized, and various types compared in reference to their relative merits for given purposes. Extensive practice should be given in the selection of individual plants for seed purposes. This is especially important now that the need for domestic seed production has been emphasized. In the corn belt states, great stress is laid upon courses dealing with the production, selection, and handling of seed corn. In states where vegetable production is a dominant feature of the agriculture, similar courses in the development of seed stocks of vegetables might well be given similar prominence. The harvesting, curing and care of seeds might either be included in such a course, or offered as a separate course which might include also a consideration of the domestic trade in vegetable seeds. Courses in systematic vegetable crops and seed production should preferably be given in the summer quarter, wherever the school year is divided into four quarters.

Various institutions offer four-year courses designed particularly for students desiring to specialize in animal husbandry, dairy manufactures, soils, field crops, pomology, floriculture or landscape gardening. A few institutions outline similar courses for students specializing in vegetable gardening. More institutions should do likewise. This is especially true in states where vegetable production is prominent. The announcement of such courses would aid in dignifying the profession of vegetable gardening, and be a means of attracting students to this important field of study and research.

REPORT OF COMMITTEE ON EXPERIMENTATION AND RESEARCH.

By W. L. HOWARD, *University Farm, Davis, California.*

Now that the greatest war of all history is over and business interests everywhere are endeavoring to get their bearings, it

should be timely for the experiment station workers in horticulture to take stock of their business and find out where they stand. Undoubtedly the war, directly and indirectly, has greatly affected our experimental and research activities, but how much and in what way? It was also desired to know what is the outlook for the immediate future.

To secure information on these points, a questionnaire was, recently sent out to the horticultural departments of the various institutions throughout the United States. It was desired especially to know whether any important experimental or research projects had to be abandoned on account of war conditions. If any projects or important parts of projects were abandoned, it was desired to know whether these station activities were discontinued:

1. Because of loss of staff members to the military service;
2. As county agents;
3. Because they left to enter some auxiliary war activity, such as the Y. M. C. A. or Red Cross; or
4. To go into business as a result of extraordinary opportunities of the difficulties or living on small salaries in war times.

Questions were also asked as to whether projects might not have been dropped for other reasons such as lack of labor caused by war conditions, special activities of the staff men in war garden work, extension work, or on account of going into some of the various manufacturing industries. Finally the opinion of the various horticultural departments was asked as to the outlook for the coming year as regards getting back on a normal basis in their station activities. While the answers are not yet all in and consequently figures cannot be given, enough replies have been received to gain a fair idea of the general situation.

Less than half of the stations reporting have had to drop experimental projects. Of those that did have to discontinue projects, nearly all had to drop them on account of loss of men, each having lost from one to five members of their horticultural staffs to the military service. Of the staff members lost to assume duties other than in the military service, the Y. M. C. A. seems to have claimed the largest number. In a few instances, but only a few, horticultural staff men were drafted temporarily by their institutions for extension service and county agent work. Regarding loss of staff men resigning to go into business, it is gratifying to record that only a very small percentage have been lured away from their station duties by high salaries offered by private work or unusual opportunities for going into business. This is a high tribute to the workers in view of the fact that salaries have in no way kept pace with increased living expenses.

A great many of the stations report a labor shortage due to their men having gone into industries especially connected with the war, but more still who were drafted into the military service direct. Only a small percentage of the stations reporting have had to reduce their activities because of lack of funds due to war time economy on the part of legislatures. This is very interesting and

an eloquent testimonial to the earnestness and fidelity of the workers that they found ways of keeping their work going when it is well known that some institutions were very much handicapped on account of diminished support from legislators. In this same connection there was some indication that moneys which ordinarily would have been spent for horticultural station work, under stress of circumstances was diverted to other lines, presumably to extension and other publicity activities. From 20 to 25 per cent of the stations reported interference with their projects because men on the staff had their time taken up with war garden and other special extension duties.

While it would seem clear that horticultural men and the industries they represent have been affected as much as business enterprises throughout the country, they have yet been able to continue their activities although one can well imagine that many of the workers did this by burning the candle at both ends.

The most gratifying feature of all the information gathered as a result of the questionnaire is the cheerful outlook for the immediate future for getting back on a normal basis. With only very slight qualifications, the answers to this question were unanimously given as "good," "fine" or "excellent."

On the whole, the agricultural experiment station work of the country was far less disturbed than the instructional work of the colleges. It is now an open secret how deans and heads of departments viewed with sinking hearts the rulings made by the special committee on war education in connection with the instruction to be given in the Students' Army Training Corps throughout the country. Agriculture, for the most part, was disregarded or ignored. While the exigencies of the situation may have justified this to a certain extent as men were being trained for active army life rather than for any kind of civilian work, it nevertheless should have been kept in view that all the young men were not apt to continue in the military service indefinitely, even though the war might have lasted for several years, many would have had to be discharged for minor disabilities so the writer cannot escape the conclusion that agriculture would have had a better hearing had it been represented on the special committee in charge of war education. That there was a lack of foresight is evidenced by the fact that the Y. M. C. A. and other auxiliary war organizations soon discovered that a very high percentage of the boys in France were interested in returning to agricultural pursuits. In fact, a far larger percentage of the men than went from agricultural pursuits expressed themselves as expecting to engage in that line of work when they returned home. To meet this need active plans for starting schools of agricultural instruction in England for the benefit of the returning soldiers were being formulated when the armistice was signed. Many of us believe that instruction such as was being planned might just as well have been given in connection with the S. A. T. C. schools throughout the country,

particularly where they were held in connection with agricultural colleges, as perhaps most of them were.

The most gratifying thought of all to look back upon is the manner in which the experiment stations were regarded by the statesmen of the country. Governmental agencies consisting of men who are far-sighted themselves had the advantage of advice and counsel from other far-sighted men apparently made up their minds quite early that experiment stations and their activities were fundamental to the welfare of our country. In other words, they were looked upon as the second line of defense, the boys at the front constituting the first line. After all, this opinion of the experiment stations is exactly in accord with the ideas held by the far-sighted statesmen who established the experiment stations in the darkest days of the Civil War. The lesson of all this is that the experiment stations have undoubtedly made good, and during our latest war, the station workers throughout the land, even in the face of excitement, patriotic fervor and economic disturbances such as will probably never again be witnessed, have continued to keep the faith.

REPORT OF COMMITTEE ON VARIETY TESTING.

By J. H. GOURLEY, *Chairman, Agricultural College, Durham, N. H.*

The Committee on Variety Testing herewith presents its second report.

The report last year consisted largely of the opinions of the various state colleges and experiment stations in regard to the advisability of maintaining large variety orchards. Various phases of this matter were discussed at that time and appear in the last annual report.

At this time the committee wishes to present a list of orchards containing rather notable collections of varieties of fruits and nuts. To make such a list entirely complete would require more time and expense than were at the command of the committee, but it is hoped that the list here given may form a nucleus for a complete list at some future time. It has been rather surprising at the small number of private orchards containing really notable collections of varieties which have been as yet reported.

AMERICAN COLLEGES AND EXPERIMENT STATIONS.

In the following list only large or notable collections of fruit and nuts are given, and it is not to be understood that these same institutions do not have lesser collections of other fruits and nuts or that institutions not listed do not have good collections.

The figures in parentheses following the kinds of fruits or nuts indicate the number of varieties reported.

- ARKANSAS Grapes (143).
- CALIFORNIA Riverside—Walnuts (25), citrus (300-400).
 Chico—Apples (48), figs (50), nectarines (18),
 olives (10), peach (40), prune (30), pomegran-
 ate (45), persimmon (70), pistache (8), pear
 (64), walnuts (18), grapes (400), etc.
 Imperial Valley—Large collection of seedlings of
 dates and pomegranates.
 Davis—Large collection—Apricot (4), almond
 (35), fig (15), English walnut (25), Japanese
 persimmon (15), pear (40), peach (87), plum
 (30), cherry (40), pecan (8), pistachio (6).
 Berkeley—Large collection of vines (vitis), nota-
 bly Vinifera, American (Labrusca, etc.), Phyl-
 loxera Resistant Stock, and miscellaneous.
- CANADA Guelph, Ont.—Apple (80), currant (60), goose-
 berry (40).
 Ottawa—A very large collection of named and
 unnamed seedlings; apples (625), plums (139,
 mostly American varieties).
- CONNECTICUT Apples (200).
- DELAWARE Apples (120), peach (80), pear (40), cherry
 (35), plum (60).
- ILLINOIS Apple (150), pear (65), peach (60), cherry (40)
- INDIANA Apple (150), plum (45).
 Indiana Hort. Society—Large collection of apple
 seedlings, etc.
- IOWA Apple (100 named, 2,500 seedlings), pear (400
 seedlings), peach (200 seedlings), plum (100
 seedlings).
- KENTUCKY Apple (130), grape (100).
- MASSACHUSETTS Apple (200).
- MARYLAND Apple (200), peach (50), grape (100), and small
 fruits.
- MICHIGAN South Haven—Apple (250), pear (75), plum
 (110), cherry (72).
- MINNESOTA Apple (200) plum (70).
- MISSOURI Apple (100) grapes.
- NEW JERSEY Peach (100 named varieties, 2,300 seedlings),
 small fruits.
- NEBRASKA Apple ((180), plum (50).
- NEW YORK Geneva—Apple (368), pear (175), quince (19),
 peach (373), plum (279), cherry (110), small
 fruits.
 Cornell—Variety collections, including large num-
 ber of seedlings of each. Apple (1,119), pear
 (502), quince (108), peach (325), plum (184),
 cherry (172), miscellaneous (182).
- NOVA SCOTIA Kentville—Apple (227), pear (55), plum (90),
 cherry (54), peach (47).
- NEW MEXICO Pear (78).
- NORTH CAROLINA Peach (80).
- OHIO Wooster—Apple (420), peach (159), plum (107),
 cherry (54).
- OREGON Pears (700 named varieties and in addition a
 larger number of seedlings), apples (1,600 seed-
 lings in addition to a large collection of named
 varieties), Large collection of nuts, small
 fruits and five-acre block of imported fruits.
- SOUTH CAROLINA Peach (95), grapes (100).

WASHINGTON, D. C... Bureau of Plant Industry—Apples (300), pear (5), quince (3), peach (100), plum (15), cherry (18), also collection of small fruits and nuts.

PRIVATE GROWERS.

The following list of private growers has been assembled who are interested in variety collections of the kinds of fruits which are listed after their names. Obviously such a list is incomplete and it may be possible to add to it substantially in the future; hence this list can serve only as a nucleus of the names which might be collected.

- ALABAMA Dr. T. H. Young, Vernon—Grapes (110), apples (31), peaches (26), pecans (14), persimmons (11), figs (5), walnuts (3).
Gulf Coast Horticultural Society—Silverhill: citrus (4), Satsuma oranges, grapefruit, Washington navel, tangerines, grapes (2), pecans (7), Japanese persimmons, number not given.
- ARIZONA G. B. Johnson, Tucson—Dates, citrus, grapes, etc., number not given.
- CALIFORNIA M. Sharpe, Vacaville—Plums (200), cherries (75), grapes (73), peaches (70), pears (50), apples (25), apricots (20), olives (15), mulberries (12), plumcots (12), English walnut (10), quinces (10), almonds (10), pomegranates (8), figs (7), oranges (3), etc.
C. P. Taft, Orange—Avocado (12), kaki (9), loquats (5), guavas (5), feijoas (2), eugenia (2), etc.
J. L. Nickel Estate, Menlo Park—Pears (220), apples (110), figs (75), peaches (75), plums (55), oranges (7), apricots (5), persimmons (5), loquats (3), and lesser number of varieties of several other fruits and nuts.
F. O. Popenoe, Altadena—Avocadoes (50), loquats (5).
William A. Spinks, Duarte—Large collection of avocado varieties.
- CONNECTICUT..... Everett E. Brown, Pomfret Center — Apples (100), peaches (20), pears (12), etc.
Gulley & Son, Rockville—Apples (78), grapes (40), peaches (17), plums (13), pears (12).
Dr. R. T. Morris, Stamford—Hickories, 9 species; walnuts, 7 species; chestnuts, 6 species; hazels, 5 species; beeches, 2 species; almond, 1 specie; pistache, 1 specie; nut-bearing pines, 10 species.
- FLORIDA Mrs. H. S. Graves, Gainesville—Pecans (18), peaches (5), persimmons (5), oranges (4), grapes (5), plums (4), grapefruit (2), kumquats (2), figs (3), guavas (2), mulberries (2).
- GEORGIA L. A. & P. J. Berckmans, Jr., Augusta, Ga.—Peaches (45), apples (27), pecans (17), figs (7), quince (4), almonds (4), walnuts (3), nectarines (3), apricots (3), etc.
- ILLINOIS Benjamin Buckman, Farmingdale—Apples (1,400), pears (40), plums (40), peaches (25), cherries (15), etc.

	Joseph Gerardi, Jerseyville—Apples (150), peaches (93), cherries (22), plums (20), pears (12), etc.
INDIANA	Benjamin W. Douglass, Trevlac—Apples (50), peaches (20). F. J. Heacock, Salem—Apples (35), nuts (4), etc. Frank Moffitt, Carmel—Apples (100), strawberries (35), peaches (25), plums (15), cherries (6). Joe A. Burton, Mitchell—Apples (38).
IOWA	F. O. Harrington, Williamsburg—Apples (200), plums (70), cherries (3), peaches (25), pears (20).
NEBRASKA	Ernest W. Pollard, Nehawka—Apples; number not given.
NEW YORK	George T. Powell, Ghent—Apples, pears, plums; number not given. Charles A. Green, Rochester—Apples (125).
OHIO	W. W. Farnsworth, Waterville—Apples (60), pears (30), peaches (25), plums (20), cherries (10). H. C. Price, Newark—Apples (100). U. T. Cox, Proctorville—Apples (100), peaches (25), pears (15), plums (15). F. H. Ballou, Newark—Apples, number not given.
OKLAHOMA	Elva C. Barrows, Tulsa—Peaches (50), plums (20), cherries (10), apples (10).
UTAH	Joseph A. Smith, Providence—Apples (20), peaches (15), nuts (13), cherries (9).
WISCONSIN	A. K. Bassett, Baraboo—Apples (25).

NURSERIES.

An attempt has been made to get in touch with nurseries which have large variety collections in bearing. While we have not corresponded with a large number of nurseries, only a small percentage of them have reported, notable collections which should be listed here. This list can doubtless be added to materially in the future.

CALIFORNIA	Loma Rica Nursery, Grass Valley—Pears (85), apples (50). Fancher Creek Nursery Co., Fresno—Apples (82), plums (75), pears (70), cherries (68), peaches (55), apricots (36), almonds (25), prunes (14), nectarines (11), quinces (7).
MARYLAND	Harrison Nurseries, Berlin—Peaches (14), apples (80), pears (20), cherries (17), plums (26), apricots (4), quinces (3). Westminster Nursery Co., Westminster—Peaches (38), apples (35), plums (15), cherries (14).
MISSOURI	Stark Bros., Stark City—Apples (300), pears (200), peaches (300), plums (100), cherries (75), quinces (10), miscellaneous (300).
NEW YORK	Ellwanger & Barry, Rochester—Pears, grapes; number not given. Maloney Brothers & Wells, Dansville—Apples (5), peaches (20), plums (20), pears (18), cherries (16), quinces (4).

West Hill Nurseries, Fredonia (Lewis Roesch)—
Grapes (71).

VERMONT George D. Aiken Nursery Co., Putney—Grapes
(50), raspberries (19), blackberries (16), etc.

REPORT OF THE COMMITTEE ON RESOLUTIONS.

WHEREAS, This Society feels itself indebted to Johns Hopkins University for its hospitality in placing rooms at our disposal; therefore, be it resolved, that we express to the President of Johns Hopkins University our appreciation of this kindness; and,

WHEREAS, Professor W. T. Maconn and Captain T. H. McHatton contributed so largely to the success and pleasure of our social evening; therefore, be it resolved, that we tender them our sincere thanks; and,

WHEREAS, Our members are to a large extent uninformed regarding the work and actions of the United States Federal Horticultural Board and feel that the regulations of this Board affect the fields of horticulture and pomology; therefore, be it resolved, that our President appoint a committee of three to compile such rulings of the Board as the committee thinks should be brought to the attention of our members.

F. N. FAGAN,
W. R. BALLARD,
W. S. BROCK,
Committee.

ITEMS OF BUSINESS.

THE FRUIT TREE FUND.

The sum of \$200.00 was donated to the War Relief Fund of The Royal Horticultural Society for the purpose of aiding in the planting of fruit trees in the devastated regions of Belgium, France and Serbia.

BOARD OF BOTANICAL ABSTRACTS.

Professors C. A. McCue and E. J. Kraus were elected to represent the Society on the Board of Botanical Abstracts.

COMMITTEES DISCONTINUED.

The Committees on Score Card and Horticultural Courses were discontinued for the time being.

LINES OF WORK CONDUCTED BY OUR MEMBERS.

Since the lines of work under way have not changed much in the last year the list will not be included in the annual report for a year or two.

OBITUARY.

Paul Edward Corriveau, head of the Department of Horticulture at Rhode Island State College, was killed in action in France, October 6, 1918. He was born in Concord, N. H., October 2, 1893, and received his education in the local schools of his native city. He graduated at New Hampshire College in June, 1915, and entered the graduate school at the University of Missouri in the fall of the same year, and received his degree of M. S. in June, 1916. In July of 1916 he entered upon his duties as head of the department of horticulture at Kingston, R. I., with the rank of instructor, where he continued to serve until he entered the service of United States Army (Marine Corps) the latter part of May, 1917.

In college Mr. Corriveau served as student assistant in the department of horticulture for two years and spent his summers in the same capacity. He was captain of the football team in his senior year.

While Mr. Corriveau had scarcely entered upon his professional career in horticulture, yet those who knew his qualities of industry, native capacity and his cordial personality predicted for him a brilliant and useful life and we are thus untimely robbed of one of the promising workers in our field. That his life was given in the service of his country in active participation in the great war for freedom is a satisfaction to those who feel his personal loss.

J. H. GOURLEY.



LIEUTENANT PAUL EDWARD CORRIVEAU.



BURR B. PRATT.

Burr B. Pratt died of influ-pneumonia at Chicago, Illinois, in October, 1918. He was born on a farm near Riverside, Michigan, May 12th, 1886. He received his early horticultural training on the large fruit farm of his father near Riverside; afterwards he entered the Michigan Agricultural College, specializing in horticulture, and was graduated from that institution in June, 1909.

Immediately after graduation he became associated with the fruit handling, transportation and storage investigations of the United States Department of Agriculture. In the course of these investigations he visited practically all the important fruit-producing sections of the country.

In the summer of 1913 he was called to the University of California as Assistant Professor of Pomology, where he acted as head of the newly created Division of Pomology of that institution.

In June, 1914, he severed his connection with the University of California and became manager of the Field Department of the California Fruit Growers' Exchange, a cooperative, non-profit, marketing organization of over 8,000 citrus fruit growers. As head of this department he had general supervision of the handling of the fruit in Exchange orchards and packing-houses. His department acted as the clearing-house through which the latest information in regard to orchard and packing-house methods was placed in the hands of the growers. His work in connection with the Field Department of the California Fruit Growers' Exchange in improving the handling methods with citrus fruits has been of inestimable value to the citrus growers of California.

In October, 1917, he was again called to the Federal Service in the Bureau of Markets, as Supervising Inspector of the North Central Division of the Office of Market Inspection of Perishable Fruits, at Chicago, remaining in the latter position until his death. In the short time in which he was in charge of the inspection work for the Chicago district he had developed his work to a high degree of efficiency, and was held in great esteem by the shippers as well as the fruit trade.

Of the younger school of horticulturists it is questionable whether any one in recent years has exerted such a wide sphere of influence and been of real help to such a large number of fruit growers as Burr Pratt.

His many friends in all sections of the country will mourn his untimely death.

L. B. SCOTT.

EDWARD F. STODDARD.

Edward F. Stoddard was born at Carbondale, Pennsylvania, May 14, 1888, and it was here that in early boyhood he learned his first lessons in vegetable growing and also in growing some of the important bush and tree fruits. He attended the town school working on his grandfather's farm in northeastern Pennsylvania during the summers.

After graduating from the Carbondale High School in 1908, he worked his way through the Pennsylvania State College, graduating in horticulture in 1913. To meet college expenses he worked during one summer vacation on a general farm near Syracuse, New York, another at the establishment of Barnes Brothers, nurserymen and orchardists, Yalesville, Connecticut. A third summer vacation period was spent on W. Atlee Burpee Company's Fordhook Trial Grounds near Doylestown, Pennsylvania, where he had an excellent opportunity to study varieties and types of vegetables.

After graduating, Professor Stoddard was appointed instructor in horticulture at the North Carolina State College where he had charge of the outdoor work in vegetable gardening on about 12 acres of ground, part of which was used for student work. In addition he had charge of the vegetable forcing work in the greenhouses. In 1915 he was appointed head of the Department of Vegetable Gardening at the Maryland State College and the following year was advanced to the position of Professor of Vegetable Gardening, which position he held at the time of his death on October 23, 1918.

Professor Stoddard took an earnest interest in furthering exhibitions and the welfare of all connected with the business of growing and marketing vegetables. For two years he acted as superintendent of the vegetable exhibits made during the Maryland Week Show at Baltimore, Maryland. The Maryland Vegetable Growers' Association was organized largely through his efforts and he ably filled the position of Secretary-Treasurer of that organization. At the college he aimed to give the students not only the scientific side, but also the kind of practical experience needed for the production of commercial vegetable crops under glass and in the field. He was untiring in his attention to detail.

He was a frequent contributor to horticultural periodicals, notably the Market Growers' Journal and the Florists' Exchange. He was a member of the American Society for Horticultural Science, the Maryland Vegetable Growers' Association, and the American Genetic Association.

He was married in 1913 to Elizabeth Archibold Summy, who survives him together with two small children. Professor Stoddard was a man of sterling Christian character and was deeply interested both in his work and in the promotion of every good cause. His untimely death brings to an abrupt close a career of unusual promise and his loss will be keenly felt in the horticultural world.

W. R. BALLARD.



EDWARD F. STODDARD



BENJAMIN MARSTON WATSON

BENJAMIN MARSTON WATSON.

Benjamin Marston Watson was born in Plymouth, Massachusetts, on November 24, 1848 and died there on February 20, 1918. He belonged to one of the old New England families and on his father's side had 18 Pilgrim ancestors. His early education was obtained in the Plymouth high school after which he entered Harvard University and graduated in the class of 1870.

In 1877 he became Instructor in Horticulture at the Bussey Institute, a department of Harvard University adjacent to the Arnold Arboretum, and remained for nearly 40 years the responsible head of the University's instruction on this subject. His courses included fruit culture and floriculture, and about 1897 landscape design from the point of view of plant material, was added. With the reorganization of the Bussey Institution in 1909, the teaching in horticulture was dropped and Professor Watson became a member of the teaching staff of the Department of Landscape Architecture of Harvard University in Cambridge. This position he held until he resigned it in the spring of 1916.

It is regrettable that with his unique first-hand knowledge of ornamental plants he left so little published material. He contributed occasionally to horticultural journals, reviews, the *Old Farmer's Almanac*, and since 1910 to *Landscape Architecture*. His articles dealt with horticultural groups with special reference to their design aspects.

He was a member of several horticultural societies and social and university clubs. He was blessed with rare social qualities and these were most happily expressed as the genial host in his own home. To be invited into his wonderful library in the house next to the Arnold Arboretum where he lived for many years, was a privilege never to be forgotten. He always had some new or "new old" book to show and comment on.

Few teachers have been more respected than was Watson, because of his seemingly inexhaustible and wholly dependable knowledge of his subject and because of his sterling character. As a teacher of horticulture in the University his place can never be filled. He was one of the last survivors of the old school of naturalists—a widely recognized expert yet not a specialist, wholly practical, yet loving the beauty of the forms it fell to him to use, and possessed of a native taste cultivated and ripened by lifelong observation and study which made him an artist in his professional work.

He will ever live in the memory of those who knew him as a rare example of transparent honesty and punctilious faithfulness to duty. He was one of the most modest of men and it has been truly said of him by one who knew him through his whole life, "I doubt if any one could do more and say less."—Extract from *Landscape Architecture*, October, 1918.

In the sudden passing of Mr. R. B. Whyte on April 15, 1918, Ottawa lost one of her most useful and respected citizens. He stood for all that was highest in the life of the city and the nation. He scorned all that was mean, dishonest, and low. His aspirations were of the noblest and the best in everything. What he accomplished is recorded in many ways and not least in the hearts of those who knew him best. The influence of the good which he did during his life will last for many a day. Old men and little children praise him. He was the greatest amateur horticulturist of his time in Canada.

While his garden contained probably the finest collection of herbaceous perennial plants of any private garden in Canada, if not in America, it was a typical home fruit and vegetable garden, and it was here that the Herbert raspberry originated in 1887. Although a lover of all kinds of fruits, his specialty among them was the English gooseberry which succeeded admirably under his attentive care. He has tested probably over one hundred of the best varieties, and left many promising seedlings which he originated. Of the herbaceous perennials he was especially interested in the peony, iris, lily, day lily, phlox and gladiolus. Among the bulbs his specialties were narcissus and Darwin tulips. He was interested in wild flowers also and made his largest herbarium collection in 1875, but has added to it each year since until it now contains most of the species found in the Ottawa District.

Mr. Whyte was an active member of many societies and had been or was at the time of his death, an officer in most of them. He belonged to the Royal Horticultural Society, the American Pomological Society, the American Peony Society, the Ontario Horticultural Association, the Ontario Fruit Growers Association, the Ottawa Field Naturalists' Club, the Ottawa Horticultural Society and the Ottawa Flower Guild. He organized and financed the Potato Growing Contests for boys in Carleton and Russell counties, and the Girls Home Guard Movement. The good results of horticultural efforts and their influence will be felt for years to come. He was a strong advocate of exhibitions, believing there was no better way to educate the public to the relative value of different plants, and he was always one of the largest exhibitors himself. He continuously offered special prizes for best exhibits and many a gardener in Ottawa has a lasting memento of Mr. Whyte in the cups he gave.

In recent years he travelled extensively during the winter months and added to his store of horticultural knowledge. He visited Bermuda, the Mediterranean Regions including the Holy Land, Jamaica and Florida. In the summer of 1912 he spent a most enjoyable time in Great Britain. He was a member of the Photographic Art Club of Ottawa and on his trips took many photographs from which lantern slides were made to illustrate his travel talks to the citizens of Ottawa. In his death Canada has lost a noble man.

W. T. MACOUN.



R. B. WHYTE.

BYRON DAVID HALSTED.

With the passing of Dr. Byron D. Halsted, the New Jersey Agricultural Experiment Station lost a faithful servant who had won honor, respect and affection from all of his associates. His unremitting search for truth added richly to our knowledge of plant diseases and of plant breeding. A pioneer in the field of mycology, he laid the foundation for much of the present-day information on plant diseases, and on this foundation his colleagues helped him to build effective methods of control. When failing health compelled him later to give up work with the microscope he devoted himself assiduously to the study of heredity and environment as factors in plant production, and, in spite of bodily suffering, retained his interest in his chosen work until the very last. Had he lived until February 1, 1919, he would have completed thirty years of service with the New Jersey Station.

Born in Venice, Cayuga County, New York, on June 7, 1852, Dr. Halsted lost his parents in early childhood and was brought up by relatives. He graduated from the Michigan Agricultural College in 1871, but remained there for two years longer in order to complete his graduate work for the master's degree. He then taught school for two years, entered Harvard in 1875, and was not only the first of Dr. Farlow's students at Harvard, but also the first to take a doctor's degree in cryptogamic botany. This degree was granted to him in 1878.

Two years after leaving Harvard he became managing editor of the American Agriculturist and remained in journalistic work until 1885. In that year the late Prof. Charles E. Bessey, on being elected Professor of Botany at the University of Nebraska, nominated Dr. Halsted as his successor at the Iowa Agricultural College. After a teaching experience of four years at Ames, he was called in 1889 to Rutgers College to become the Botanist of the Experiment Station and Professor of Botany in the College.

Dr. Halsted was associate editor of the Bulletin of the Torrey Botanical Club from 1890 until 1893, and of Systematic Flora of North America since 1895. He won the silver medal of the Massachusetts Horticultural Society in 1877. The scientific societies in which he held membership included the American Association for the Advancement of Science, the Society for the Promotion of Agricultural Science (president 1897-1899); The Botanical Society of America (president 1900-1901); and the Society of Plant Morphology and Physiology. He was the author of "The Vegetable Garden," 1888; "Farm Conveniences," 1888; "A Century of Agricultural Weeds," 1891; and of numerous technical papers in bulletins, reports and journals.

Dr. Halsted was a very enthusiastic botanical collector and a great many new species were brought to light as a result of his enthusiastic work. He described a number of new species and sent many more to Ellis, Everhart and other mycologists. He was among the first to report the introduction of several foreign diseases into America.—From *The Voorhees Farmer*, October, 1918.

JACOB G. LIPMAN.

NOTE.—The Secretary was unable to secure photo of Dr. Halstead.

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J. W. CROW

PROCEEDINGS
OF THE
American Society
FOR
Horticultural Science
1919

Sixteenth Annual Meeting, St. Louis, Missouri
December 29, 30 and 31, 1919

Published by the Society
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College Park, Maryland

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OFFICERS AND COMMITTEES FOR 1920

<i>President</i>	W. H. ALDERMAN
<i>Vice-Presidents</i>	{ M. J. DORSEY J. H. GOURLEY W. H. CHANDLER
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<i>Assistant Secretary</i>	R. F. HOWARD

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J. W. CROW	C. P. CLOSE, <i>Secretary, ex-officio</i>
	L. GREENE

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R. W. REES, <i>Chairman</i>	E. C. AUCHTER
J. G. MOORE	R. E. MARSHALL
	E. F. PALMER

PROGRAM

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RESEARCH AND EXPERIMENTATION

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T. H. MCHATION	R. W. REES	J. W. CROW

BOTANICAL ABSTRACTS

C. A. MCCUE	E. J. KRAUS
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A. A. A. S. COUNCIL

C. P. CLOSE

NATIONAL RESEARCH COUNCIL

U. P. HEDRICK

CONSTITUTION

ARTICLE 1

The name of this Association shall be the American Society for Horticultural Science.

ARTICLE 2

The object of the Society shall be to promote the Science of Horticulture.

ARTICLE 3.

Any person who is a graduate of an agricultural college and holds an official position in an agricultural college, experiment station, or federal Department of Agriculture in the United States or Canada, may become a member upon payment of the annual dues of \$1.50.

ARTICLE 4

Meetings shall be held annually at such time and place as may be designated by the Executive Committee, unless otherwise ordered by the Society.

ARTICLE 5

The officers shall consist of a President, three Vice-Presidents, and a Secretary-Treasurer, who, together with the chairmen of the standing committees, shall constitute a Council to act upon all applications for membership. There shall also be an Assistant Secretary. These officers shall be elected annually by ballot.

ARTICLE 6

This Constitution may be amended by two-thirds vote of the Society at any regular meeting, notice of such amendment having been read at the last regular meeting

BY-LAWS

SECTION 1. The President and other officers shall perform the usual duties of their respective offices. The President shall also deliver an address at each regular meeting.

SEC. 2. There shall be a Committee on Nominations consisting of five (5) members, who shall be nominated and elected by ballot at each regular meeting of the Society. It shall be the duty of this committee, at the following meeting, to suggest to the Society names for officers, referees, and members of committees for the ensuing year.†

SEC. 3. There shall be an Executive Committee, consisting of three (3) members and the President and the Secretary, ex-officio. This committee shall perform the usual duties devolving upon such committee.

SEC. 4. The Committee on Nominations shall nominate referees and alternates upon special subjects of investigation or instruction, which may be referred to its consideration by the Society. The duties of these referees shall be to make concise reports upon recent investigations or methods of teaching in the subjects assigned them, and to report the present status of the same.

SEC. 5. There shall be a Committee on Program, consisting of seven (7) members, of which the Secretary shall be one. This committee shall have charge of the scientific activities of the Society, except as otherwise ordered by the Society.

SEC. 6. The annual dues of the Society shall be one dollar and fifty cents.

SEC. 7. Ten members of the Society shall constitute a quorum.

*The Constitution and By-Laws as amended from time to time.

†Since 1913 two lists of candidates have been required.

MEMBERSHIP ROLL FOR 1919

ABELL, T. H.	Agricultural College of Utah, Logan, Utah.
ALDERMAN, W. H.	University Farm, St. Paul, Minn.
ALLEN, F. W.	624 Miller Building, Yakima, Washington.
ANDERSON, J. P.	Juneau, Alaska.
ANDERSON, O. G.	Purdue University, Lafayette, Indiana.
ANTHONY, R. D.	Experiment Station, State College, Pa.
AUCHTER, E. C.	Maryland State College, College Park, Maryland.
AUSTIN, C. F.	Finca Laguna, Herradura, Cuba.
BARCOCK, E. B.	University of California, Berkeley, California.
BAILEY, E. W.	University of Illinois, Urbana, Illinois.
BAILEY, L. H.	Ithaca, New York.
BALLARD, W. R.	Experiment Station, College Park, Maryland.
BARNETT, R. J.	State College of Washington, Pullman, Wash.
BARRON, LEONARD	Garden City, New York.
BARSS, A. F.	University of British Columbia, Vancouver, B. C.
BATCHELOR, L. D.	Citrus Experiment Station, Riverside, California.
BEACH, F. H.	Ohio State University, Columbus, Ohio.
BEACH, S. A.	Iowa State College, Ames, Iowa.
BEAL, A. C.	Cornell University, Ithaca, New York.
BEATIE, W. R.	U. S. Dept. Agr., Washington, D. C.
BEAUMONT, J. H.	University Farm, St. Paul, Minn.
BENNETT, E. R.	Extension Service, Boise, Idaho.
BIOLETTA, F. T.	University of California, Berkeley, California.
BLAIR, J. C.	University of Illinois, Urbana, Illinois.
BLAIR, W. S.	Experiment Station, Kentville, Nova Scotia.
BLAKE, M. A.	Experiment Station, New Brunswick, N. J.
BRIERLY, W. G.	University Farm, St. Paul, Minnesota.
BROCK, W. S.	University of Illinois, Urbana, Illinois.
BUCK, F. E.	Central Experimental Farm, Ottawa, Canada.
BUSHNELL, J. W.	University Farm, St. Paul, Minn.
CADY, LEROY	University Farm, St. Paul, Minn.
CARDINELL, H. A.	University of Missouri, Columbia, Mo
CARRICK, D. B.	139 North Clark St., Chicago, Ill.
CALDWELL, J. S.	U. S. Dept. Agr., Washington, D. C.
CHANDLER, W. H.	Cornell University, Ithaca, New York.
CHENOWITH, W. W.	Agricultural College, Amherst, Mass.
CLARK, C. F.	U. S. Dept. Agr., Washington, D. C.
CLEMENT, F. M.	University of British Columbia, Vancouver, B. C.
CLOSE, C. P.	U. S. Dept. Agr., Washington, D. C.
COIT, J. E.	University of California, Berkeley, California.
COLBY, A. S.	University of Illinois, Urbana, Illinois.
CONDIT, I. J.	University of California, Berkeley, California.
CONNORS, C. H.	Experiment Station, New Brunswick, N. J.
COOPER, J. R.	University of Arkansas, Fayetteville, Arkansas.
CORRETT, L. C.	U. S. Dept. Agr., Washington, D. C.
CRAIG, A. G.	East Farms, Washington.
CRANDALL, C. S.	University of Illinois, Urbana, Illinois.
CRANE, H. L.	University of West Virginia, Morgantown, W. Va.
CROW, J. W.	Agricultural College, Guelph, Canada.
CRUICKSHANK, R. B.	Ohio State University, Columbus, Ohio.
CULLINAN, F. P.	Purdue University, Lafayette, Indiana.
CULVERHOUSE, P. E.	Hort. Experiment Sta., Vineland Sta., Ont., Can.
CUMMINGS, M. B.	Experiment Station, Burlington, Vermont.
DACY, A. L.	Massachusetts Agricultural College, Amherst, Mass.
DARROW, G. M.	U. S. Dept. Agr., Washington, D. C.

- DAVIS, M. B. . . . Dominion Experimental Farm, Ottawa, Canada.
 DAVIS, V. H. . . . State Department of Agriculture, Columbus, Ohio.
 DEAN, M. L. . . . Horticultural Commissioner, Olympia, Wash.
 DEARING, CHARLES . . . U. S. Dept. Agr., Washington, D. C.
 DEBAUN, R. W. . . . Seabrook Farms, N. J.
 DETJEN, L. R. . . . Experiment Station, West Raleigh, N. C.
 DICKENS, ALBERT . . . Agricultural College, Manhattan, Kansas.
 DORSEY, M. J. . . . University Farm, St. Paul, Minnesota.
 DRAIN, B. W. . . . Massachusetts Agricultural College, Amherst, Mass.
 DRINKARD, JR., A. W. . . Experiment Station, Blacksburg, Virginia.
 DURST, C. E. . . . Farm Bureau, Anna, Illinois.
- EDMINSTER, A. F. . . . Spring Brook Farm, East Freetown, Mass.
 ERWIN, A. T. . . . Iowa State College, Ames, Iowa.
 EUSTACE, H. J. . . . San Francisco, Calif.
- FAGAN, F. N. . . . Experiment Station, State College, Pa.
 FARLEY, A. J. . . . Rutgers College, New Brunswick, N. J.
 FAROUT, F. W. . . . Missouri Fruit Station, Mountain Grove, Mo.
 FISHER, D. F. . . . Wenatchee, Washington.
 FLETCHER, S. W. . . . Pennsylvania State College, State College, Pa.
 FLETCHER, W. F. . . . Pleasant Grove, Utah.
 FROST, H. B. . . . Citrus Experiment Station, Riverside, California.
 FLOYD, B. F. . . . 722 West Bay Street, Jacksonville, Florida.
- GARDNER, V. R. . . . University of Missouri, Columbia, Mo.
 GOODING, J. H. . . . State College of Washington, Pullman, Wash.
 GOULD, H. P. . . . U. S. Dept. Agr., Washington, D. C.
 GOURLEY, J. H. . . . Agricultural College, Durham, New Hampshire.
 GREEN, L. . . . Purdue University, Lafayette, Indiana.
 GRIFFITHS, DAVID . . . U. S. Dept. Agr., Washington, D. C.
- HANSEN, N. E. . . . Agricultural College, Brookings, South Dakota.
 HEDRICK, U. P. . . . Experiment Station, Geneva, New York.
 HEINICKE, A. J. . . . Cornell University, Ithaca, New York.
 HENDRICKSON, A. H. . . University Farm School, Davis, Calif.
 HIGGINS, J. E. . . . Experiment Station, Honolulu, Hawaii.
 HODGDON, R. W. . . . 357 Court Street, Los Angeles, California.
 HOLLISTER, S. P. . . . Agricultural College, Storrs, Connecticut.
 HOLMES, F. S. . . . Experiment Station, College Park, Md.
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 HOOKER, H. D. . . . University of Missouri, Columbia, Mo.
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MULFORD, F. L.	U. S. Dept. Agr., Washington, D. C.
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TREASURER'S REPORT FOR 1919

Voucher No.	Cr.		
1918			
(1) Dec. 30	Expenses of Secretary in attending the 1918 meeting at Baltimore	\$ 13.34	
(2)	George E. Melvin, Annapolis, Md.		
	300 programs	\$8.50	
	500 envelopes	3.50	
	Postage	.17	
			12.17
1919			
Jan. 11	Stamps		2.00
Jan. 30	Stamps		2.00
(3) Feb. 14	Maurice Joyce Engraving Co., Washington, D. C.		
	5 copper half-tones at \$3.00	\$15.00	
	one line engraving	2.50	
	Trimming plate and re-blocking	.30	
			17.80
Feb. 24	Stamps		2.00
(4) Feb. 25	Thomas & Evans Printing Co., Baltimore, Md.		
	2000 letter heads	10.50	
	1800 envelopes	10.00	
	Postage	.38	
			20.88
Mar. 7	Stamps		1.00
Mar. 10	Stamps		4.00
(5) Mar. 11	Royal Horticultural Society for the War Relief Fund for planting fruit trees in Belgium, France and Servia	200.00	
Mar. 21	Stamps		1.00
Mar. 29	Stamps		3.00
Apr. 17	Stamps		1.00
(6) Apr. 30	Cash book		1.15
(7) May 3	Thomas & Evans Printing Co., Baltimore, Md.		
	350 copies of 1918 Report, 126 pages at \$1.78 per page	225.54	
	Excess composition 8 pt. above 10 pt.	9.48	
	25 additional proofs of membership list	1.65	
	Postage on 194 reports from Baltimore to members	14.81	
	Cartage from Baltimore to College Park	1.00	252.48
May 3	Stamps		1.00
May 21	Stamps		1.00
July 1	Stamps		1.00
(8) Oct. 7	Two phone messages to George T. Melvin, Annapolis, Md.	.70	
Oct. 8	Stamps		1.00
Oct. 10	Stamps		5.00
Nov. 29	Stamps		1.00
Dec. 3	Stamps		2.00
(9) Dec. 17	J. R. Risdon, printing 350 programs of 1919 meeting	17.00	
(10) Dec. 18	J. R. Risdon, 500 letter heads \$2.50, 500 envelopes \$2.50	5.00	
(11) Dec. 26	Torsch & Franz Badge Co., New York, N. Y., report 1917	7.05	
	To balance		301.78
			\$877.35
1919			
	Dr.		
Jan. 4	By balance on hand	\$412.85	
Jan. 4	J. A. Nelson, Geulph, Canada. Report 1917	1.50	
Jan. 4	Hill & Coy, Fort William, Ontario, report 1917	1.50	
Jan. 10	American Manganese Co., Chicago, Illinois, report 1917	1.50	
Jan. 11	Utah Agricultural College, Logan, Utah, report 1917	1.50	
Jan. 18	The Baker & Taylor Co., New York, N. Y., report 1917	1.50	
Jan. 20	F. E. Buck, Ottawa, Canada, report 1917	1.50	

Feb. 10	University of Arkansas, Fayetteville, Ark., reports 1903 to 1917 inclusive.	14.00
Feb. 25	Cornell University, Ithaca, N. Y., reports 1916 and 1917	3.00
Mar. 13	O. F. Whitney, Topeka, Kansas, reports 1917 and 1918	3.00
Apr. 14	Arnold Arboretum, Jamaica Plain, Mass., reports 1903 to 1918 inclusive	15.50
Apr. 14	American Forestry Co., Boston, Mass., report 1918.	1.50
Apr. 14	Kentucky Agricultural Experiment Station, Lexington, Ky., report 1918	1.50
Apr. 17	Cornell University, Ithaca, N. Y., report 1918.	1.50
Apr. 18	C. H. Myers, Ithaca, N. Y., report 1917	1.50
Apr. 19	Ohio State University, Columbus, Ohio, report 1918.	1.50
Apr. 22	G. E. Stechert & Co., New York City, report 1918	1.50
Apr. 28	Agricultural Experiment Station, Experiment, Ga. Report 1918	1.50
Apr. 30	University of Minnesota, St. Paul, Minn., report 1918	1.50
Apr. 30	Iowa State College, Ames, Iowa, report 1918.	1.50
Apr. 30	Utah Agricultural College, Logan, Utah, report 1918.	1.50
Apr. 30	Massachusetts Horticultural Society, Boston, Mass., reports 1905 to 1918 inclusive except for 1911	13.50
May 3	State College of Agriculture, Athens, Ga., report 1918	1.50
May 12	Agricultural Experiment Station, Blacksburg, Va., report 1918	1.50
May 12	University of British Columbia, Vancouver, B. C., report 1918	1.50
May 12	Purdue University, Lafayette, Indiana, report 1918	1.50
May 12	State Department of Agriculture, Harrisburg, Pa., report 1918	1.50
May 14	Cecil H. Hooper, Wye, Kent, England, report 1917.	1.50
May 14	University of Missouri, Columbia, Mo., report 1918.	1.50
May 22	University of California, Berkeley, Cal., 3 reports for 1918	4.50
May 24	University of Wisconsin, Madison, Wis., report 1918.	1.50
May 24	Massachusetts Agricultural College, Amherst, Mass., report 1918	1.50
June 20	State Agricultural College, Fort Collins, Colorado, report 1918	1.50
June 20	Brooklyn Botanic Garden, Brooklyn, N. Y., report 1918	1.50
June 20	G. E. Stechert & Co., New York City, reports for 1917 and 1918	3.00
June 20	Oregon Agricultural College, Corvallis, Ore., reports for 1917 and 1918	3.00
June 20	Southern Oregon Experiment Station, Talent, Ore., report 1918	1.50
June 20	New Mexico College of Agriculture, State College, New Mexico, two reports for 1918	3.00
June 20	R. Veterinary and Agricultural College, Copenhagen, Denmark, report 1918	1.50
June 30	The Northern Ontario Plant Breeding Station, Fort William, Ontario, reports 1905 to 1916 inclusive, except for 1911.	10.50
June 30	University of Vermont, Burlington, Vt., report 1918.	1.50
July 29	University of Maine, Orono, Maine, report 1918	1.50
Aug. 4	Department of Agriculture, Harrisburg, Pa., reports 1905 to 1918 inclusive, except for 1911	13.50
Aug. 5	C. G. Vinson, Ithaca, N. Y., report 1918	1.50
Aug. 29	University of Nebraska, report 1918	1.50
Oct. 27	Princeton University, Princeton, N. J., reports 1905 to 1918 inclusive except for 1911.	13.50
Nov. 15	State College of Washington, Pullman, Wash., report 1918	1.50
Nov. 24	Ohio State University, Columbus, Ohio, report 1919	1.50
Dec. 13	E. B. Babcock, Berkeley, Ca. if., report 1916	1.50
Dec. 28	Dues paid since last meeting.	310.50
		\$877.35
Balance on hand.		\$301.78

Respectfully submitted,

C. P. CLOSE, Treasurer.

The Auditing Committee reported that it had examined the accounts of the Treasurer and found them to be correct.

W. H. CHANDLER,
T. H. MCHATTON,
W. R. LESLIE,
Auditing Committee.

ANNUAL MEETING AT ST. LOUIS, MO.

DECEMBER 29, 30 AND 31, 1919

The meeting was called to order by President Crow who presided at all of the sessions. About 65 members were in attendance during the meeting, though not at any one session, and visitors from other societies were present most of the time. The joint session with the Botanical Society of America and the American Phytopathological Society at the Missouri Botanical Garden, was one of the main features of the meeting and was attended by about 250 people. President Crow was requested to preside at this session.

The program was longer than ever before, the papers were of a high order, the discussions were snappy, and the general opinion prevailed that this was the best meeting we have ever had. In order that we may not need to break up into sections as the Society increases in numbers and usefulness, the wish was expressed that speakers should not take time to read long papers, but rather present and discuss their main points and submit the entire paper for publication in the annual report.

Progress in Apple Breeding for the Canadian Prairies

By W. T. MACOUN and M. B. DAVIS,

Central Experimental Farm, Ottawa, Canada

THE Canadian prairies, or the greater part of them, are situated between latitude 49° and latitude 53° (except the isolated prairies of the Peace River district, which are further north), and between longitude 97 on the east to longitude 114 on the west. While a large proportion of this area is practically treeless, there are portions of it which are more or less covered with trees, the principal of which are the aspen, balsam, poplar, box elder, American elm, green ash, canoe birch, mossy cup oak, tamarac, white and black spruce, and jack pine, but the commonest tree is the aspen, *Populus tremuloides*. The lowest elevation on the prairies is at the south-east corner, where it is about 700 feet, while the highest elevation is 4,200 feet.

The spring is early on the prairies, and warm days in April cause the buds to swell, and growth begins just about the same season as it does in Ontario. The summers are relatively warm, though the nights are cool, particularly at the higher altitudes, and ripening is not so rapid as it is in Ontario where the nights are much warmer. Winter usually sets in during the latter part of October or early in

November, or about a month sooner than it does in Eastern Ontario. The winter temperatures are often very low, sometimes being from 40° F. to 50° F. and lower below zero. The most trying times on trees appear to be, first, in the spring after buds swell or leaves have begun to unfold when severe late spring frosts, which are of fairly frequent occurrence, will kill all growth; second, in late autumn or early winter when trees will be badly frozen while the foliage is still on the trees; and, third, the long continued spells of severe cold, which the old timers think reduce the moisture in the trees so much that they die. However, all of these factors require closer investigation. Whatever the main cause is, the fact remains that it has been found difficult and practically impossible over most of this great area to bring trees of the varieties of apples at present in commerce to a bearing age. For the past thirty years a very large number of varieties have been tested at the Experimental Stations and by private individuals in Manitoba, Saskatchewan, and Alberta, but it may be said that few trees have borne, and, when they have, they have not lived long afterwards. An exception to this general rule is found in Southern Manitoba, where the altitude is lowest and where there are a few orchards of bearing trees, one of which produces in one year from 200 to 300 barrels of apples, mainly of such varieties as Oldenburg, Charlamoff, Blushed Calville, Ostrakoff, and Hibernial.

What has been said about the tenderness of apples applies also to the hybrid crab apples usually offered for sale, they also proving too tender except in Southern Manitoba. Among these may be mentioned Transcendent, Hyslop, Florence, Virginia, and Martha.

It will thus be seen that there is a great field for work for the apple breeder to originate varieties which will succeed on the higher elevations of the Canadian prairies.

Fortunately, there is hardy foundation stock on which to work. The Siberian Crab Apple (*Pyrus baccata*) is a native of Siberia, Manchuria, Korea, and other north Asiatic countries. It grows very far north in Asia. Where it is wild it withstands as severe or more severe climatic conditions than it gets on the Canadian prairies. The fruit of this crab apple varies from the size of a pea to about three-quarters of an inch in diameter. It is usually very astringent. It fruits well on the Canadian prairies in most places where it has been tried.

In 1887, or about thirty-two years ago, seed of *Pyrus baccata* was obtained from the Imperial Botanic Gardens, Petrograd, Russia, and sown at Ottawa. In 1890, young trees were sent to the Experimental Farm at Brandon, Manitoba, and Indian Head, Saskatchewan. These proved entirely hardy, and in 1894, when some trees from this lot were blooming and fruiting well, it was thought by the late Dr. William Saunders, then Director of the Dominion Experimental Farms, that by crossing *Pyrus baccata* with the hardiest varieties of apples, new varieties would be obtained which would be hardy enough to withstand the severe climatic conditions of the Canadian prairies and be large enough and good enough in quality to compare favorably with the better sorts already in commerce. In this

work *Pyrus prunifolia* was also used as a parent. Crossing was begun in 1894. As this work has already been described several times, it may be but briefly referred to here. Some 800 trees of the F_1 generation were grown. The wild crab has been the mother unfortunately in every instance, there being 21 varieties of apples used as male parents.

The fruit of the *Pyrus baccata* tree used by Dr. Saunders as a female parent was from one-half to three-quarters of an inch in diameter. The largest of the F_1 offspring were from one and one-quarter to one and three-quarters inches in diameter. From one standpoint the results were disappointing as the size was so small, but it marked a step in advance. The better varieties have little or no astringency and compare favorably in quality with the best named crab apples on the market. Nearly all of them retained the marked crab characteristics of long, slender stems; thin tender skin; and crisp, breaking flesh. The best of these F_1 crosses were named, propagated and sent to about 200 places in the Canadian Northwest, representing altitudes ranging from 740 to 4,200 feet, the first distribution being made in 1902. At the lower elevations, as in Southern Manitoba, most of these proved quite hardy, and if the fruit had been larger would have been quite satisfactory, but at the higher elevations and in exposed situations only two out of the seventeen best have, after a thorough test since then, proved sufficiently hardy for the most exposed and trying places. These are Columbia and Osman, and a description of these follows as they may yet play an important part in the development of hardy apples for the Canadian prairies.

Columbia is a cross between *Pyrus baccata* and Broad Green, the latter being a summer Russian variety which has since died at Ottawa, and did not show any great hardiness. The original description of this variety, Columbia, as made by Dr. Saunders, is as follows: "Tree a very strong grower and a fair bearer. Fruit, size 1.8 inches across and 1.6 inches deep, nearly conical, distinctly ribbed, and clayx protruding and persistent; stem of medium length; color, red with stripes and dots of a deeper shade; flesh, yellowish, lightly streaked with red, juicy, subacid, with a pleasant flavor, slightly astringent; quality, fair to good; season, late September and October."

"Osman (*Pyrus baccata* with Osimoe). Tree a fair grower and a good bearer. Fruit, above medium size, a little smaller than Transcendent; color, pale yellow well washed with crimson; flesh, tender, breaking; flavor, acid but pleasant, only slightly astringent; season, latter half of August." The name Osimoe is a synonym of the Beautiful Arcade, also known as Good Peasant, Herren, and Repka Kislag, and has proven to be one of the hardiest Russian apples tested in Canada. It is a sweet apple ripening in August.

In 1904, Dr. Saunders re-crossed what he considered were the best of the F_1 crosses with the apple, using eighteen varieties of apples, in the hope of originating varieties that would retain enough of the character of hardiness to withstand the severe climatic conditions of the Canadian prairies and would be larger in size than the F_1 gener-

ation. At that time he thought that practically all of them would continue hardy, but subsequently many of them were badly winter-killed under the severest tests on the prairies. There were 407 trees obtained of these second crosses, the first of which began to fruit in 1910. A large proportion of these were planted at Ottawa, and descriptions were made of 223 of the trees which fruited. The fruit of 171 of these or 76.68 per cent was under two inches in diameter or little or no larger than the fruit from the F_1 crosses. The fruit of 48 or 21.52 per cent was between 2 and 2.25 inches in diameter, and three were between 2.25 and 2.5 inches in diameter or 1.35 per cent. There was one above 2.5 inches in diameter, namely 2.62 inches or 45 per cent. It will thus be seen that a second infusion of apple blood increased the size of the fruit considerably, though gave no fruit above the smallest marketable size for an apple. Most of these second crosses have the long, slender stems, the thin, tender skin, and the crisp, breaking flesh, which are characteristic of the crab apple. Judging by the very few varieties from the F_1 generation which have proved hardy under the most trying conditions on the prairies, it is very doubtful if any of these second crosses will prove hardy at the high altitudes, but already several of these have fruited at the Experimental Station at Morden, Manitoba, and it is hoped that some of them will be considerably hardier than the Russian apples and will extend the area over which apples can be grown.

Following are more detailed results from certain of these second generation crosses where there were sufficient trees of a cross to give a fair indication of what might be expected if the numbers were still larger.

THE PIONEER CROSSES

Pioneer a seedling from the cross *P. baccata* X Tetofsky, when crossed with McIntosh, N. Spy, Cranberry Pippin and Ontario gave some rather interesting results. This variety (Pioneer) was 1.5 inches in largest diameter, yellow in color with a pink cheek, of medium quality and nearly round in shape.

Considering the increase in size due to the seeded infusion of the blood of orchard varieties, let us compare the results from these different crosses where different varieties were used as male parents.

No. of trees	Cross	Mean inches	Mode inches	Model Coefficient per cent	inches	Extremes inches
17	Pioneer X Ontario	1.81	1.75	29.4	1.375	2.375
40	Pioneer X Northern Spy	1.71	1.75	30.0	1.375	2.250
7	Pioneer X McIntosh	1.92	2.00	71.44	1.625	2.000
14	Pioneer X Cranberry Pippin	1.74	1.75	28.55	1.500	2.000

The largest percentage of comparatively large sized apples came from the cross Pioneer X McIntosh, when 71.44 per cent of the seedlings gave fruit 2 inches in diameter, while the mean for all the seedlings was 1.92 inches. None of the fruit from this cross was as small as some of the fruit from the other three, while both Ontario

and Northern Spy crosses gave a few fruits considerably larger than any from the McIntosh cross.

Quality: In the transmission of the factor for quality these different male parents appear as follows:

No. of trees	Cross	Good per cent	Above		Below	
			Medium	Medium	Medium	Poor
			per cent	per cent	per cent	per cent
17	Pioneer X Ontario	11.76	11.76	64.70	—	11.76
40	Pioneer X Northern Spy	5.00	17.5	45.00	10.00	22.5
7	Pioneer X McIntosh	14.28	28.56	57.14	—	—
14	Pioneer X Cranberry Pippin	7.14	7.14	57.14	7.14	21.43

Here again we have the McIntosh outstanding in its influence on the progeny. Over 14 per cent of its seedlings were good in quality and none below medium. Why Northern Spy should not have exerted as great an influence as Ontario is difficult to understand unless it can be dismissed with the theory that Ontario carries the factor for quality inherited from its parent Northern Spy and its parents, to a greater degree than is evidenced from the fruit itself. At this point it might be well to note that one of the best of the second crosses in so far as size and quality are concerned is Wapella, a seedling from Dean X Ontario. Dean itself is a result of a cross between *P. baccata* X Wealthy. From this cross Dean X Ontario, 33 per cent of the seedlings were above medium and good in quality, while when McIntosh was used as a pollinizer 42.9 per cent were above medium to good. Dean itself was one of the poorest of the first crosses.

It is here seen that the male parent exerted a tremendous influence on the quality of progeny and further that if the male is descended from a line of ancestors possessing high quality it may, although not possessing this factor to a very highly developed degree, somatically transmit the factor for quality very efficiently.

It should further be stated that the largest number of high class second crosses has come from Prince X McIntosh, thus again showing the value of McIntosh as a parent. Prince is the result of a cross between *P. baccata* and Tetofsky.

The results from this lead us to assume for the present that if a high class of progeny is desired a parent or parents possessing these characters to a very highly developed degree should be used.

Our work has not lead us to believe in the theory of variable prepotency of varieties in transmitting their characters, but has rather convinced us of the necessity of choosing as one of the parents a variety possessing the desired character developed to the highest possible degree of perfection.

TRANSMISSION OF PREDOMINANT COLOR

In considering the inheritance of color, the colors have been classified under three headings (1) where yellow predominates, (2) where reds or shades of crimson predominate, (3) where there is an equal distribution of red and yellow shades.

Tabularly arranged, the same four crosses just discussed appear as follows:

Cross	With Yellow Predominant per cent	With Red Predominant per cent	With equal Distribution per cent
Pioneer X Cranberry Pippin ..	50.00	42.80	7.20
Pioneer X McIntosh	25.00	75.00	—
Pioneer X N. Spy	36.83	52.78	10.08
Pioneer X Ontario	23.52	52.35	23.52

As was before stated Pioneer itself was mostly yellow with a pink cheek. When crossed with Cranberry Pippin, not a highly colored variety, the majority of the seedlings had yellow in predominance while on the other hand when crossed with such a highly colored sort as McIntosh, 75 per cent of the resultant seedlings had red as a predominant color. The same held true to a lesser degree for Northern Spy and Ontario both moderately highly colored varieties.

This paper would not be complete without further reference to the use of McIntosh as a parent, and a more detailed account of the Prince X McIntosh seedlings is here appended. Eight of these have been described.

The mean size of all the seedlings of this cross which have fruited to date is 1.94 inches, or almost 2 inches in diameter. This record is only approached by the mean of the Pioneer x McIntosh seedlings. The mode however, is only 1.5 inches and the modal coefficient 25 per cent, but the extremes range from 1.25 inches to 2.625 inches, the latter being the largest of the second crosses.

Thirty-seven per cent of the seedlings from this cross have been so good as to warrant a name and another 37 per cent are good enough for further trial, while only about 25 per cent have been discarded, so that at every turn the value of McIntosh Red, that king of apples, as a parent, is evident.

In addition to hand pollination for the purpose of obtaining hardy varieties of apples for the prairie provinces of Canada, many seedlings resulting from open pollination are being tested. In an orchard at the Central Experimental Farm, Ottawa, there is a large number of Russian varieties. From the fruit of some of the hardiest and best of these, seed was taken and sown in the autumn of 1910, and the yearling trees resulting from this seed were sent in 1912 to seven experimental stations on the Canadian prairies. In addition to this, seed was obtained from fruit of the same varieties which had matured in Southern Manitoba. Altogether some 75,000 seedlings have been sent to these stations. These were planted in nursery rows three feet or more apart with the plants a foot or less apart in the rows. In Southern Manitoba a large proportion of these have proved hardy so far, but at the higher altitudes practically without exception the trees have killed back, and from experience to date it would not seem that there is much likelihood of obtaining hardy varieties in this way. Evidently there must be more blood of the *Pyrus baccata* put into even the hardiest Russian apples to obtain varieties that will withstand the severest tests on the Canadian prairies, and it is in this direction we shall continue to work using *Pyrus baccata* as the male parent rather than the female as it is believed a large percentage of the F₁ crosses will be apples of marketable size, and at least a few may prove hardy.

Breeding Methods with Horticultural Plants

By J. W. CROW, *Ontario Agricultural College, Guelph, Canada*

HORTICULTURAL plants embrace so wide a list of species and varieties that some effort at classification seems almost necessary as a preliminary to any intelligent discussion of the principles and methods which are of interest to the plant breeder. The following classification is incomplete, but may perhaps serve to group our materials and assist in the planning of improvement work in the several classes. It will also serve to point out some important gaps in our knowledge, because it is of first importance in breeding operations to know whether a given plant produces seed by cross-pollination or self-pollination, and whether the reverse process is possible. It is also important to know the duration of life of the plants in question and how they are propagated.

PLANT BREEDERS' CLASSIFICATION OF PLANTS

1. *Propagated by Seed only.*
 - A. *Annuals.*
 - Cross—Capable of self—corn
 - Cross—Incapable of self—spinach
 - Self—Capable of cross—pea, aster, lettuce
 - Self—Incapable of cross—(?)
 - B. *Biennials.*
 - Cross—Capable of self—beet, onion
 - Cross—Incapable of self—some varieties of cabbage
 - Self—Capable of cross—parsnip, celery
 - Self—Incapable of cross—(?)
2. *Seed or Spore Producing Perennials.*
 - A. Propagated in nature principally by seeds or spores
 - Cross—Capable of self—rhubarb; various fruit species and varieties
 - Cross—Incapable of self—asparagus, self-sterile fruits, dioecious grapes
 - Self—Capable of cross—perennial pea
 - Self—Incapable of cross—ferns(?)
 - Parthenogenetic—Requiring pollination—lilium species
 - Not requiring pollination—hieracium(?)
 - B. Propagated in nature principally by division.
 - Cross—Capable of self—strawberry
 - Cross—Incapable of self—pistillate strawberries
 - Self—Capable of cross—potato
 - Self—Incapable of cross—ferns(?)
3. Non-seed producing perennials—various potato varieties, *L. tigrinum* and other liliums, horse-radish.

PRINCIPLES OF EVOLUTION

Biologists are now able to define the principles of organic evolution and plant breeders are under the necessity of recognizing these as fundamental to plant improvement work.

The main principles of biological evolution are:

- (1) Isolation of strains of heredity.
- (2) Recombination of characters by crossing.

The first is based on the power of heredity and is expressed in the old adage "Like begets like". Most biologists agree that the isolation of mutations is at the basis of organic evolution. The role of hybridization in bringing about new combinations of characters is now well understood.

PRINCIPLES OF PLANT BREEDING

These appear to the writer somewhat as follows and as already stated are based on the principles above formulated.:

1. Isolation of mutations,
 - (a) As practiced with self-fertilized plants.
 - (b) As practiced with cross-fertilized plants.
2. Recombinations of characters by crossing.
 - (a) As used with plants which are required to breed true from seed. Dominance usually occurs here and recombination is looked for in the second generation.
 - (b) As used with plants which are propagated asexually and which are not required to breed true from seed. Dominance is seldom obvious and recombination is looked for in F_1 .

The basis of improvement in the isolation of mutations is the breeding power of the individual and the method is in general simply that of saving seed from each parent plant separately and testing out the resulting progenies as individual progeny lots under uniform conditions. In self-fertilized plants the method is very easy of application and quick results. It is the principal method which has been made use of up to the present time in cereal improvement and in our own experience has given excellent results with lettuce and celery. The former is strictly self-fertilized and the latter appears to cross-pollenize only very slightly, if at all, as is proven by the striking uniformity of progenies grown from individual parent plants, even when no steps are taken to prevent cross-pollination. Parsnips also show most decided individuality in progeny lots and in most cases a surprisingly high degree of uniformity.

In cross-pollenized seed plants the individual plant progeny test is slower of results, but is nevertheless of great value. Crops such as beets, onions, cabbage and corn show striking differences in breeding power in spite of the large amount of cross-pollination which normally takes place.

Our results with onions would suggest that in this group quicker results may be had by selfing, where possible, and individual plants self-fertilized have given us in most cases a much higher percentage

of desirable progeny than we have obtained with material which was allowed to cross-pollenize naturally. We have, therefore, adopted this method with all plants of this class. In onion improvement we grow our choicest stock under glass and self-pollenize carefully by hand, using manila sacks as covers to prevent crossing. We have not been successful in self-fertilizing beets or carrots under paper sacks and are now adopting the plan of isolating single roots out-of-doors.

The loss of vigor which is known to accompany self-fertilization is often urged against this method of breeding, but it is probable that the objection is not a serious one. It would appear from the work of Jones of Connecticut, that so soon as crossing is again allowed to take place one may expect to recover all that has been lost.

There is very great need for careful experimentation in order to determine the extent to which plants of this group and others which are normally cross-pollenized may be induced to set seed by self-fertilization.

It is interesting to know that besides securing quick isolation of high class strains, this method also uncovers cases of extreme variation within the offspring of one parent. Within the progeny of one onion bulb, self-fertilized, we have found the widest possible variation in type. With gladiolus, also, we find that where one plant may produce offspring showing more or less uniformity, another plant may give rise to extreme variations with respect to size, color, form of flower, season of bloom, etc. This fact suggests that in asexual plants selfing may perhaps provide the best means of bringing to light the extreme characters which are often of such great importance to the breeder. At any rate it seems beyond dispute that crossing tends to cover up the extremes while selfing tends to bring them out.

Where it is desired to recombine characters the method is that of simple crossing or hybridizing, with which we are all fully familiar. With plants which are desired to breed true from seed, it would no doubt be well to purify the parent strains, or varieties, before crossing. It is probable that a great deal of the disappointment experienced by breeders in the past has been due to the use of material carrying undesirable characters. It will be obvious that where the strains are purified before crossing, the chances of getting the desired combination are greatly increased. The crossing of such purified strains would result in Mendelian dominance and necessitate going to the second generation in order to secure the desired recombinations.

It should also be obvious that the correct principle of mating varieties, or strains, which it is desired to cross, involves duplicating the good qualities in both parents whenever possible and offsetting always an undesirable trait in one parent with a corresponding good trait in the other. It is desirable, also, in selecting parents for crossing not to go any farther away in relationship than is necessary in order to do this and at the same time gain the inclusion of characters which it is desired to recombine in the progeny.

A large number of horticultural plants are propagated asexually and fall into the classes not required to breed true from seeds. It is probable that most horticultural perennials, including all varieties of

fruit, are heterozygous with respect to most characters and where two such are crossed recombination is looked for in F_1 . As has been already suggested in the foregoing, certain individuals of such a cross would throw extreme variation in the second generation if self-fertilized, but, in general, there seems to be no rule by which one may know whether the maximum variation has been obtained in F_1 , or whether it might possibly be increased by going to F_2 . In short-lived plants of this class it might often be practicable to carry on to the second generation by self-fertilization, thereby insuring the widest possible variation and the most pronounced segregation. In long-lived plants of this class, such as fruit trees, it will probably be found impracticable to proceed in this fashion because of the long-time nature of the operations and because of the self-sterility of many varieties.

A great many of our most important plant breeding problems center around the matter of combining vigor, or constitution, with what we call the finer qualities, such as flavor and texture in fruits and vegetables, or size, color and aroma in flowers. In all these cases it would appear that the direction in which the cross is made is a matter of very great importance. If we were aiming to produce the highest possible percentage of strong, robust seedlings, it would of course be desirable to select a mother parent possessing these qualities. It seems to be the fact that, in general, plants inherit type and constitution more largely from the mother than from the pollen parent. In all these cases which are now under discussion, however, we are concerned not with the percentage of robust seedlings, but with the occasional seedling which combines in fullest measure the constitution of one parent and the finer qualities of the other. It happens that we have available for breeding purposes very few plants which possess this happy combination to begin with. In general, the species and varieties of most robust vigor are lacking in the finer qualities, while those which are noteworthy for their fine qualities are often lacking in constitution. There is evidence to suggest that perhaps the better way to make the cross is to use the higher quality plant as seed parent and the robust one as pollen parent. The writer is inclined to the opinion, based on extensive work with strawberries, that it is possible by this method to eliminate a very much larger percentage of seedlings in the first two or three years. It is probable that as good plants can be produced one way as the other, but certainly the time and space required for testing seedlings can be greatly reduced by the following plan. Our experience is that if the robust plant is used as mother parent, we get a large percentage of seedlings of robust constitution and require to spend years of time in testing them out.

There are so many cases of this kind that perhaps to mention a few examples would be the best way of bringing out my meaning. In strawberries it would indeed be an achievement worthy of note if one could combine the vigor, hardiness and productiveness of the American varieties with the size and flavor of the best European sorts. We have been working on this problem for some time but have only now waked up to the fact that we have been going the

wrong way about it. In rhubarb we have varieties possessing both size and quality, but I know of no variety with the necessary size and productiveness and which is also high class with respect to red color. In gladiolus, H. H. Groff, veteran gladiolus breeder and producer of many of our choicest varieties, has always used the method I am now describing. Mr. Groff's most recent work has been done in the yellow section and he has successfully combined the clear yellow of the *Primulinus* species with the large size and improved form of the best cultivated sorts. Mr. Groff uses always the finest domestic forms as mother parents. In the breeding of roses it is much to be desired that the hardiness and disease resistance of such species as *Rugosa* should be combined with the long stem, large size, and exquisite form of the best Teas and Hybrid Teas. Whether the perfect combination is attainable or not, there is certainly room for very great improvement, and as herein suggested the correct procedure would probably be to use pollen of the hardier species and raise seedlings from Teas and Hybrid Teas.

In tree fruits, where winter hardiness is of such very great importance, it is probable that the method herein suggested would give better results than the reverse practice, which latter is much more commonly followed. A great deal of breeding for hardiness in apples has been done in the past, but up to the present the results are scarcely proportional to the amount of work done. It is probable, however, that this apparent failure can be accounted for by the use of the crab parent as mother. It seems to be the fact that apple seedlings inherit size of fruit in the majority of cases from the seed parent, and since it has been clearly proven that hardiness can be transmitted through the pollen parent, it follows that the correct procedure is probably to use the small-fruited, hardy parent as pollinizer and the large fruited, tender variety as seed parent.

Disease resistance is of prime importance with many horticultural plants and breeding for disease resistance offers many interesting problems. Unfortunately, we are not offered by plant physiologists and pathologists so much encouragement in this connection as we should like. Dr. Edward M. East is of the opinion that differences in virulence of different strains of the same organism may be just as great, if not greater, than the differences in resistance of cultivated plants. His view is supported by that of other excellent authorities and by experimental evidence. It is probably also supported by the experience of plant breeders of whom some have found that varieties resistant in certain climates or localities are not so resistant when grown elsewhere. This matter is one which demands the fullest possible inquiry. Until fuller information is available probably the only thing we can do is to go ahead with our breeding work. If it succeeds, well and good, if not, we shall have to investigate the reasons for failure. There would appear to be no good reason why the resistance to apple scab which is in general characteristic of such varieties as Ribston, Blenheim Orange and others, may not be incorporated into such varieties as McIntosh, thereby greatly lessening the risk of loss and reducing the cost of production. It is likewise earnestly to be hoped that the work of Dr. Hansen and others in breeding for blight resistant pears, may be wholly successful.

In all of this work it is well to keep in mind that the particular disease being worked on must be given every opportunity of infecting the seedling stock; if necessary the plants being tested for resistance, should be inoculated. With pears this can be easily done by the use of unsterilized pruning tools. In such cases as that of breeding beans for resistance to anthracnose it can easily be done by spraying the spores of the disease on the plants and maintaining moist, close conditions for 24 hours.

You may probably have noted that no mention has been made of a principle of breeding, commonly designated as "Selection". You may have noted, also, that no mention was made of such a process in discussing biological evolutions. It seems to me it is high time we define the word "selection", and that we should no longer confuse it with the process which is best described as "isolation". Isolation is the ground work of practically all plant and animal breeding and consists in the segregation of a type or a line of heredity which was there all the time and which is only brought to light through being segregated. The sense in which Darwin used the word "selection" implies a gradual change of a cumulative nature in each successive generation. It seems fairly well established that selection within a strictly pure line is not capable of bringing about any great change. In some cases it is impossible, of course, to say where isolation ceases and selection begins, but to the writer it appears that "isolation" expresses the fundamental idea of most improvement work much better than does the word "selection". Such characters as vigor and constitution seem to be cumulative in nature, and in these cases selection may be the right word although it is well known that in many cases vigor is transmitted as a unit, and may be isolated by the same process of segregation which is ordinarily applied in the simple plant progeny test.

Some Notes on the Inheritance of Unit Characters in the Peach

By C. H. CONNORS, *New Jersey Agricultural Experiment Station, New Brunswick, N. J.*

This paper presents the data secured from the first crop picked from the first generation seedlings from crosses among commercial varieties of peaches. Two thoughts are behind the paper. The first is to present what evidence has been secured of scientific interest. The second thought is that the data herewith presented may be of some assistance to others working along the same lines. This is with the idea of fostering the spirit of cooperation. I take it that our society is founded with this end in view, and more could be accomplished in lines of research if reports of progress could be made from time to time, especially with respect to a long time proposition such as breeding tree fruits. Publication of such data would enable

new investigators in the field to avoid certain pitfalls that are likely to occur, thus saving much valuable time.

The primary object of this experiment is, of course, the improvement of our existing varieties. The second object is to study the inheritance of various characters, with the idea in mind that possibly light will be thrown on the classification of peach varieties and races, if such there be.

SELECTION OF PARENTS

The parents used in one series of crosses were Elberta, Belle, Greensboro, and Early Crawford.

Elberta and Belle were selected because they are two of the most widely grown varieties. Elberta, although the most adaptable variety in the list of commercial varieties, could be improved in flavor and in "irritability," or tendency to start into growth during warm spells in winter. Belle has this same failing to a lesser extent. Both of these varieties are supposed to be seedlings of Chinese Cling, with the possibility that Early Crawford was the pollen parent of Elberta, and Old Mixon of Belle. Chinese Cling is the progenitor of one of our so-called races of peaches, the North China Cling group. The variety Chinese Cling was not available, so Greensboro was selected, this variety being, as far as our knowledge goes, a line descendent from Chinese Cling. Greensboro is one of our hardiest and most prolific varieties. Early Crawford represents the so-called Persian group. In the other series, St. John was used as the seed parent and Early Wheeler and Greensboro as the pollen parents.

METHOD OF WORK

The technique of handling the blossoms and the resulting seedlings were described in a previous paper.*

INFLUENCE OF CROSSING ON PERIOD OF BLOOM

The weather during the blooming period was very disagreeable. Rain fell on four days (April 12, 15, 16, 17). This, with cold, damp weather, was responsible for extending the length of the blooming period.

Bloom started on April 8. Record was made of first bloom only, but this means not the first blossom but the apparent beginning of the real period of bloom. The latest trees to bloom had first bloom on April 20. Table I shows the number of seedlings resulting from the various pollinations that had first bloom on the various dates.

It will be noted that the greatest number of trees had first bloom in the period from April 10 to 13, inclusive. This was the normal period of first bloom for the varieties used. Several of the seedlings had first bloom on the 17th, 18th, 19th, and 20th.

*Proc. A. S. H. S. 1917.

TABLE I—NUMBER OF PEACH SEEDLINGS HAVING FIRST BLOOM ON VARIOUS DATES IN APRIL, 1919

	8	9	10	11	12	13	14	15	16	17	18	19	20
Belle S. P.	0	6	21	12	29	69	34	1	0	4	16	4	1
Elberta S. P.	0	2	18	11	40	37	9	1	0	1	5	3	2
Belle X Elberta	2	9	13	4	14	21	2	2	0	0	1	0	0
Elberta X Belle	0	1	21	4	23	36	3	0	0	1	1	2	0
Belle X Early Crawford .	2	13	19	1	14	39	1	0	0	1	0	0	0
Early Crawford X Belle .	0	0	4	1	6	14	1	0	0	0	0	0	0
Elberta X Early Crawford .	1	14	13	8	22	18	2	0	0	0	0	0	1
Early Crawford X Elberta .	0	1	12	3	13	12	0	0	0	0	1	0	0
Belle X Greensboro . . .	3	19	79	11	34	82	5	2	0	0	6	0	1
Elberta X Greensboro . .	3	18	34	4	20	21	2	0	0	1	3	0	0
Early Crawford S. P. . .	1	4	14	3	16	18	1	0	0	0	3	0	0
Early Crawford X Greensboro	0	13	13	2	4	7	0	0	0	0	0	0	0

This may have been accidental, due to the growing condition of the tree at the time the blossom buds were formed, for the trees were young and made a very vigorous growth late into the summer, so that what fruit buds were set were not so well matured and consequently opened later.

If this late blooming were not accidental, the condition is very desirable, as such seedlings would not be irritable.

INHERITANCE OF SIZE OF BLOSSOM

As notes were not made on all the trees, some not blooming, the data here given are incomplete for the total number of trees planted; but certain conclusions may be drawn from the data so far gathered.

The blossoms of peaches may be arranged in three groups as to size: large, medium, and small. This applies to the aspect of the whole flower. The differentiation between the large and the medium sized blossoms is quite distinct. The petals of the large size may vary somewhat, ranging from 13mm. to 18mm. wide and from 17mm. to 20mm. long. The differentiation between the medium sized blossoms and the small sized blossoms is not quite so marked, but a distinction can be drawn. The small sized blossoms have petals ranging from 5 mm. to 6mm. wide and from 7mm. to 10mm. long. The petals of the medium sized blossoms range from 7 mm. to 9mm. wide and from 9mm. to 13mm. long. In some cases the petals of the medium sized blossoms do not spread out, making the blossom appear small. However, the blossoms of the small type have petals that are somewhat spatulate, while those of the medium size have petals rather ovate in shape.

The classification of the peach has hinged to a certain extent upon the size of the blossoms. It is now known, however, that peach trees having all three sizes of blossoms are formed in China and sometimes all three forms may be found in the same locality.

Under an older classification, two races were recognized, those having large blossoms and those having small blossoms. It seemed to the writer that possibly the medium sized blossom might be an

intermediate or "hybrid" type, since Elberta and Belle, believed to be the result of a cross between large and small blossomed varieties, both have the medium sized blossom.

SMALL BLOSSOMS, SELF-POLLINATED

The variety bearing small blossoms that was used in this work for self-pollination was Early Crawford. Records were kept of the bloom of 50 trees of Early Crawford self-pollinated. Of these, 46 bore small sized blossoms and 4 bore blossoms having petals 7mm. by 9mm. and 7mm. by 10mm. The probability is that the latter four measurements, because of delay in securing them, were from small blossoms which were very mature, since the expansion after maturity is about 1 mm.

LARGE BLOSSOMS, SELF-POLLINATED

Unfortunately, the variety bearing large blossoms that was used in this series does not mature seeds. Greensboro is an early variety, ripening about 80 days after blooming. It was found that the germ developed, but that the cotyledons did not mature fully.

In a later series another large-blossomed variety was used, but these will not bloom until the spring of 1920.

SMALL BLOSSOM CROSSED WITH LARGE BLOSSOM

Observations were made on 28 trees of the first generation of a cross between Early Crawford (seed parent) and Greensboro (pollen parent). All the seedlings have medium sized blossoms. In another series, St. John (small blossom) was crossed with Greensboro (large blossom) and with Early Wheeler (large blossom). All the seedlings (19 in the first instance and 30 in the second) had medium sized blossoms.

MEDIUM SIZED BLOSSOMS

Table II gives the total number and the number of large, medium and small blossoms of seedlings of Elberta Self-Pollinated, Belle Self-Pollinated, Belle X Elberta and Elberta X Belle.

TABLE II

	Large		Medium		Small		Total
	No.	Per cent.	No.	Per cent.	No.	Per cent.	
Belle Self-Pollinated	26	15.4	103	61.0	40	23.7	169
Elberta Self-Pollinated	29	21.5	64	47.4	42	31.0	135
Belle X Elberta	16	24.6	38	58.5	11	16.9	65
Elberta X Belle	12	15.4	55	70.5	11	14.1	78
Total	83	18.6	260	58.2	104	23.3	447
Mendelian ratio	111.8	25.0	223.5	50.0	111.8	25.0	—

These figures seem to indicate that the medium sized blossom is an intermediate, as when crossed among themselves or selfed, the seedlings split up into approximately the Mendelian ratio for hybrids, large blossoms being dominant.

MEDIUM CROSSED WITH SMALL AND SMALL CROSSED WITH MEDIUM SIZED BLOSSOMS

Table III gives the results from seedlings secured by crossing Belle and Elberta with Early Crawford, and the reciprocals.

TABLE III

	Large		Medium		Small		Total
	No.	Per cent.	No.	Per cent.	No.	Per cent.	
Belle X Early Crawford .	1	0.8	76	63.3	43	35.8	120
Elberta X Early Crawford .	11	14.1	46	59.0	21	26.9	78
Totals	12	6.1	122	61.6	64	32.3	198
Early Crawford X Belle . . .	—	—	21	80.8	5	19.2	26
Early Crawford X Elberta . .	—	—	21	50.0	21	50.0	42
Totals	—	—	42	61.8	26	38.2	68

The number of individuals is relatively small, so no definite conclusions can be drawn. In the first set, the Mendelian ratio would seem to work out, with the large petalled flower dominant. The reciprocals, however, do not seem to bear this out entirely, as no large petals occurred, but the population is small.

MEDIUM CROSSED WITH LARGE BLOSSOMS

Belle and Elberta were crossed with Greensboro, and the results are shown in Table IV. As previously noted, no reciprocals are possible where Greensboro is used.

TABLE IV

	Large		Medium		Small		Total
	No.	Per cent.	No.	Per cent.	No.	Per cent.	
Belle X Greensboro	56	31.8	114	64.8	6	3.4	176
Elberta X Greensboro	41	45.6	42	46.7	7	7.8	90
Totals	97	36.5	156	58.7	13	4.9	266

Here again is an indication of the dominance of the large petalled flower.

While no definite conclusion can be drawn as a result of one generation, the indications seem to point to two pure types of bloom, the large and the small, with the medium sized blossom as an intermediate.

CORRELATIONS

At this time attention is called to two correlations in characters of the peach. Hedrick* established a correlation between the color of the inside of the calyx cup and the color of the flesh of the fruit. When the calyx cup is greenish, the fruit will be white and where the calyx cup is a deep orange, the flesh of the fruit will be yellow. An intermediate type is found in which the calyx cup is yellowish buff, and following this the color of the flesh will be white, but the tree carries a character for yellow flesh. This is true in the case of Belle.

Another correlation is that between the leaves and the color of the flesh. In a general way an observation of the color of the foliage will serve to indicate the color of the fruit, for where the leaves are a dark green, white fleshed fruits are found and where the leaves have a yellowish cast (excepting, of course, injured trees), the color of the fruit will be yellow. This correlation seems to be quite definite, but an examination must be made of the veins. When the midrib and veins of the leaves of a tree have a yellowish cast, the fruit is yellow; but if the midrib and veins are a pale green or whitish, the fruit will be white. Use of these two correlations will be made later.

RIPENING DATES

The ripening dates of the various varieties concerned in this discussion were as follows, the date being that of the first picking: Early Wheeler, July 17; Greensboro, July 27; Carman, August 8; Early Crawford, August 20; Belle, August 27; Elberta, September 4. St. John did not ripen fruit this season, but the date for this variety would have been about August 14.

Belle S. P. The first of 95 seedlings to fruit ripened on August 13 and the last one on September 16. The largest group, 38, ripened approximately with Belle. between August 25 and 29. Another group of 19 ripened from the 16th to the 18th and a group of 15 from August 31 to September 2. None ripened after September 8 until the last one on September 16.

If Belle is a seedling of Chinese Cling X Early Crawford, the early ripening group would be explained, although it is a few days earlier than Early Crawford. The late ripening group practically coincides with the ripening date of Chinese Cling.

Elberta S. P. Only 38 seedlings from this parentage fruited. The first one ripened on August 11 and the last one on September 8. The majority ripened from August 31 to September 4. This would bring the greatest number to ripeness at the Elberta season.

Early Crawford S. P. The seedlings of this parentage were planted in 1917, so were in their third season, and only six bore fruit. These were scattered over the period from August 11 to 31, and are not sufficient in number to give any indication of how the date of ripening is inherited.

*Hedrick, U. P. "Peaches of New York."

Belle X Elberta. The first to ripen in this lot were picked on August 22. A well defined group was picked between August 25 and 29 and another group between September 1 and 7. Twenty-one fruited at approximately the Belle season and 33 at approximately the Elberta season which would seem to indicate a slight prepotence of Elberta with respect to this character.

Elberta X Belle. The first of this group to ripen matured its fruit on August 22 and the last on September 9. The majority (33 out of 36) matured between August 28 and September 3, beginning about with Belle and lapping over into the Elberta season. Almost all ripened within the limits of the two varieties, which themselves lap.

Belle X Early Crawford. Sixty-five seedlings from this cross fruited. The first ripened on August 8 and the last on September 6. There are four groups with the limits and numbers as follows: August 15-18, 18; August 21-25, 18; August 28 to September 2, 25; September 4-6, 4. The first group corresponds with Early Crawford; the third group about with Belle. The second group is an intermediate and the last group reflects the ripening date of Chinese Cling, parent of Belle and also of Late Crawford, parent of Early Crawford.

Early Crawford X Belle. Only eight of this cross fruited this season, extending from August 12 to September 2. The indications are that the results with respect to this character will be approximately the same as in the reciprocal of the cross.

Elberta X Early Crawford. Thirty one seedlings of this group fruited, ripening from August 18 to September 7. The majority (25) ripened from August 30 to September 2, just a little before Elberta. One ripened August 18, about the Early Crawford season and five from September 5 to 7, about the season of Late Crawford and Chinese Cling.

Early Crawford X Elberta. These 22 seedlings began to ripen on August 27 and the last one ripened on September 3, with the majority between August 29 to September 1. This is approximately the same as in the reciprocal.

Belle X Greensboro. This group comprised 113 seedlings. Only 1, ripening on July 21, approached the ripening date of the pollen parent; 68 ripened in the period between August 7 and 12, which approximates the Carman season and is about midway between the season of the parents. From July 30 to August 6, 18 ripened and from August 13 to 18, 25 matured. One matured on August 30. This seems to indicate a compromise with the influence apparently slightly in favor of Greensboro. Now Greensboro is believed to be a seedling of Connet, which ripens at the same time with Carman.

Elberta X Greensboro. This group of 34 commenced to fruit on August 2, the last one ripening on September 1. There is one group of 10 trees ripening in the period from August 2 to 7, another group of 22 in the group ripening between August 11 and 17, one tree which ripened on August 28 and one on September 1. The number of individuals is smaller than in the case of Belle X Greensboro, but the tendency with respect to date of ripening seems to be about the same.

Early Crawford X Greensboro. Only six from this cross fruited, the dates of ripening extending from August 11 to 31. The number of individuals is too small to draw any conclusions.

St. John X Early Wheeler. Twenty from this cross ripened. The earliest was July 18 and the last August 7. These extend from about the Early Wheeler season not quite to the season of St. John, showing the strength of Early Wheeler in the direction of setting forward the date of ripening.

St. John X Greensboro. Only 7 of these fruited, the first on July 25, the season of Greensboro, and the last on August 1, about half way between Greensboro and St. John.

It is evident from the foregoing statements that where such relatively pure varieties are bred, we do not obtain the great extremes of periods of ripening obtained from promiscuous crossing or sowing open pollinated seeds of some varieties. The tendency seems to be mainly an influence to attain the ripening periods of the parents, with a few apparently atavistic individuals. Future generations, however, may upset these results.

INHERITANCE OF COLOR OF FLESH

The study of the inheritance of the color of flesh in peaches is complicated by the possible and probable variation in genetic constitution for this character. While peaches are known to be generally self-fertile, the possibility of cross-pollination under orchard conditions is always present. Since most of our peach varieties are chance seedlings, we do not know, with any certainty, what these varieties carry as recessives in flesh color. An example of this is the variety Elberta. This variety is known to be a seedling of Chinese Cling. If Chinese Cling were pure white, and were crossed with a yellow variety, then all of the seedlings in the F_1 generation should be white, unless color of flesh is a sex-linked character. In the F_2 generation, we would expect splitting up. However, Elberta, as the F_1 , is yellow, while Belle, a seedling of the same variety, is white.

In table V are shown the number and percentage of fruits having white or yellow flesh and the probable number and the percentage having white and yellow flesh among those seedlings that have not fruited. This latter data is based on the double correlation of foliage, color and the color of the calyx cup.

We can consider this only as the F_1 generation of parents of unknown constitution, and of course cannot draw any very definite conclusions from the results. Several facts, however, stand out. Belle carries a factor for yellow of about 25 per cent. When Belle is crossed with a variety that is considered pure white, Greensboro, no yellow fleshed fruit was obtained, although probably 6 will be found among the seedlings that did not ripen. Basing our percentages on the total number of trees 97.5 per cent will be white and 2.5 per cent will be yellow. When Belle is crossed with a variety always supposed to be pure yellow as to flesh, Early Crawford, we shall probably have about one-third white and two-thirds yellow. In the reciprocal,

TABLE V.—INHERITANCE OF COLOR OF FRUIT IN THE F₁ GENERATION, NUMBER AND PER CENT. OF WHITE AND YELLOW

	Fruited				Not Fruited				Total			
	White		Yellow		White		Yellow		White		Yellow	
	No.	Per cent.	No.	Per cent.	No.	Per cent.	No.	Per cent.	No.	Per cent.	No.	Per cent.
Belle S. P.	66	69.5	29	30.5	109	77.8	31	22.2	175	74.5	60	25.5
Elberta S. P.	3	7.3	38	92.7	1	1.0	99	99.0	4	2.8	137	97.2
Belle X Elberta	31	58.4	22	41.6	5	33.3	10	66.7	36	52.9	32	47.1
Elberta X Belle	16	44.4	20	55.6	24	40.7	35	59.3	40	42.1	55	57.9
Belle X Early Crawford .	27	41.5	38	58.5	22	37.9	36	62.1	49	39.9	74	60.1
Early Crawford X Belle .	5	66.5	3	37.5	10	50.0	10	50.0	15	53.6	13	46.4
Elberta X Early Crawford	6	19.4	25	80.6	6	13.0	40	87.0	12	15.6	65	84.4
Early Crawford X Elberta	0	—	22	100.0	—	—	20	100.0	0	—	42	100.0
Belle X Greensboro . . .	113	100.0	0	—	123	95.4	6	4.6	236	97.5	6	2.5
Elberta X Greensboro . .	33	97.2	1	2.8	74	89.2	9	10.8	107	91.4	10	8.6
Early Crawford X Greensboro	16	100.0	0	—	23	100.0	0	—	39	100.0	0	—
Early Crawford S. P. . . .	1	16.7	5	83.3	2	3.5	55	96.5	3	4.8	60	95.2
St. John X Early Wheeler	20	100.0	0	—	27	100.0	0	—	47	100.0	0	—
St. John X Greensboro . .	7	100.0	0	—	17	100.0	0	—	24	100.0	0	—

Early Crawford X Belle, the percentages will be about 50-50, thus indicating a slightly different effect depending on the direction in which the cross was made. When Belle is crossed with Elberta, possibly a sister, or at least a step-sister, we find 52.9 per cent white and 47.1 per cent yellow, but where Elberta is crossed with Belle, we find practically a reversal of the percentages of white and yellow, although with a sufficiently large population a 50-50 result might have been obtained.

Elberta S. P. gives 2.8 per cent white fleshed fruits. If we are to go upon the assumption that this generation is the F_2 of a cross between Chinese Cling and a yellow variety, then the expectation would be at least 25 per cent white, which leads to the thought that perhaps Chinese Cling is not a pure white and that the classification of peaches into the various groups is based upon a fallacious assumption.

When Elberta is crossed with Early Crawford (supposed to be its pollen parent) we obtain about one-eighth whites, while the reciprocal gives all yellow fleshed fruits. In the latter the population is small and a few more trees might easily change the results. It would seem, however, that the difference here is again due to the direction of the cross. Elberta X Greensboro gives 91.4 per cent white and 8.6 per cent yellow, showing the dominance of the white flesh over yellow flesh.

Early Crawford S. P. gives 4.8 per cent of the seedlings bearing white fleshed fruits. This variety has always been considered a pure yellow. Belonging to the group having small blossoms, which are more likely to self-fertilize, we should expect that it would be more nearly pure than some of the other varieties. However, the parent of this variety, Late Crawford, throws a considerable proportion of white fleshed seedlings from open pollinated seeds, which would lead us to expect the recessive white. When Early Crawford is crossed with Greensboro, all of the seedlings bear white-fleshed fruit, showing the dominance in the F_1 of white over yellow.

St. John X Early Wheeler gave all white in the F_1 and St. John X Greensboro likewise.

CONCLUSIONS

We know nothing of the nature of the yellow coloring matter in the peach, although it seems to be a sap color.

It would seem that a cross between a pure white and a pure yellow would give all white flesh in the F_1 .

In crossing commercial varieties we are dealing with unknown genetic constitution, and so cannot prophesy what will happen in later generations.

Wherever a white fleshed variety is crossed upon a yellow fleshed variety, the seedlings show a marked increase in vigor over that of the yellow parent. This is especially true where Greensboro is used.

ADHESION OF FLESH TO STONE

In these crosses, only freestones and clingstones were used. There is a difference in the adhesion of flesh to stone between Early Wheeler and Greensboro, the former being very clingy and the latter less so,

but not enough to be classed as a semi-cling under the climatic conditions in New Jersey.

The relation of the semi-clingstones is not clear. They seem to be border line cases in that under varying climatic or weather conditions they sometimes become cling and at other times almost free.

Where freestones are self-pollinated or crossed with other freestones, as shown in Table VI, a large proportion of the seedlings, varying from a little more than 50 per cent, in the case of Early Crawford X Elberta to 100 per cent in the case of Early Crawford self-pollinated, are freestones. Only a few of the Early Crawford self-pollinated seedlings ripened, so that the data for this variety are not conclusive. However, in the Belle X Early Crawford and reciprocal, and Elberta X Early Crawford, from 67.8 per cent to 80 per cent of the seedlings were freestones. Both Belle and Elberta seem to carry a factor for clinginess of about one-third, as about two-thirds of the seedlings are freestones.

When freestones are crossed with clingstones, a higher proportion of clingstones is secured. Elberta X Greensboro, however, gives a larger percentage of freestones than does Belle X Greensboro. This might be expected, judging from the behavior of Elberta and Belle when self-pollinated, Elberta S. P. giving a slightly greater per cent of freestones than Belle S. P.

TABLE VI—ADHESION OF FLESH TO STONE

	Total	Freestone		Semi-Cling		Clingstone	
		No.	Per cent.	No.	Per cent.	No.	Per cent.
Belle S. P.	95	61	64.3	14	14.7	20	21.0
Elberta S. P.	41	29	70.8	1	2.4	11	26.8
Belle X. Elberta	53	34	64.2	3	5.6	16	30.2
Elberta X Belle	36	25	69.5	5	13.9	6	16.6
Belle X. Early Crawford	65	52	80.0	1	1.5	12	18.5
Early Crawford X Belle	8	6	75.0	0	—	2	25.0
Elberta X Early Crawford	31	21	67.8	1	3.2	9	29.0
Early Crawford X Elberta	22	12	54.5	2	9.1	8	36.4
Belle X Greensboro	113	37	32.7	50	44.3	26	23.0
Elberta X Greensboro	34	14	41.2	10	29.4	10	29.4
Early Crawford X Greensboro	16	5	31.2	4	25.0	7	43.8
Early Crawford S. P.	6	6	100.0	0	—	0	—
St. John X Early Wheeler	20	0	—	3	15.0	17	85.0
St. John X Greensboro	7	2	28.6	0	—	5	71.4

The effect of the difference in relative clinginess of Early Wheeler and Greensboro is shown in the seedlings. St. John X Early Wheeler gave no freestones, while St. John X Greensboro gave 28.6 per cent free. The population in the latter case is very small.

Further crosses have been made in an effort to ascertain the relationship of the semi-cling group, and also of the clingstone group. One point was made very clear in the series under discussion, and that

is that it is impossible to secure viable seeds from the early season clingstone varieties.

CONCLUSION

Freestone X freestone gave about two-thirds freestone seedlings and one-third either semi-cling or cling.

Freestone X clingstone gave a large proportion of clingstone seedlings, varying with the degree of clinginess of the parents and with the power of the freestone parent to produce freestone seedlings.

ECONOMIC ASPECT

The fruit of each seedling as picked and described was classed according to its economic value. "Desirable" means that the individual could be planted in a commercial way, but not necessarily that it is worthy of propagation and dissemination. The other classes are "may be desirable", "not very desirable" and "not desirable". In the latter class are placed most of the clingstones and those of markedly poor desert quality. Those classed "may be desirable" were many of them as good as some of the varieties now grown. The fruit from these was marketed in a local market which would take fruit that could not be handled in a larger market.

Of the 546 seedlings described, 155 or 28.3 per cent were classed as "desirable," 156 or 28.7 per cent as "may be desirable," 80 or 14.7 per cent, as "not very desirable" and 155 or 28.3 per cent as "not desirable." Some of these in the latter class were marketed, so that about 75 per cent of all the seedlings yielded fruit that could be sold in a local market.

There do not seem to be any records of earlier experiments in crossing peaches. From promiscuous sowing of seeds, it is gathered from reports that usually only a small percentage of the seedlings yield marketable fruit. That these seedlings secured from crossing known parents should be so far superior to the run of "mongrel" seedlings seems to be due to the quality of the parents used in the crosses, each one of which has one or more outstanding desirable characters.

As for the possibilities for new or improved varieties, one year's test is, of course, not sufficient. However, a number of these seedlings are outstanding and have been propagated for further trial. Among these are:

1. Several seedlings of Belle X Greensboro, freestones, oval in shape, of very bright color, resistant to brown rot, vigorous and productive, ripening at the season of Carman;

2. A seedling of Belle X Early Crawford ripening at the time of Champion, round in shape, freestone, a vigorous grower, having the flavor of Champion, but resistant to brown rot;

3. Several seedlings of Belle X Early Crawford that resemble Belle in shape but have the color of Early Crawford, of good quality and ripening about the season of Belle;

4. A seedling of Early Crawford X Elberta, resembling Elberta in shape and color but of superior quality, ripening about one week before Elberta.

SUMMARY

As stated at the beginning, the object of this paper is not so much to lay down any definite scientific conclusions respecting the inheritance of unit characters in the peach, as to set forth the data secured in order that others working along the same line may have the information in the hope that it may be of some assistance.

The fruiting of the remainder of the seedlings may change the results herein given, as it has been found that frequently some variation may be continuous in a row for a number of trees and then give way to some other variation, only to appear again later.

The general results are these:

Elberta carries white flesh as a recessive character to the extent of about one-third. It seems prepotent with respect to ripening period. Its character for quality is only mediocre.

Belle is strongly white, but seems to carry a 25 per cent character for yellow. It is prepotent with respect to vigor and quality and carries a factor for clinginess of about 25 per cent.

Early Crawford is almost pure yellow. Its character for quality seems dominant as does its character for freestone.

Greensboro seems to be pure white, is clingstone but carries a small factor for freestone.

White on yellow gives increased vigor.

White seems to be dominant over pure yellow in the F_1 generation.

Asexual Inheritance in the Violet

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This paper will be published as a technical bulletin; no other information available when this report was printed.

Some Characteristics of Open-Pollinated Seedlings of the Malinda Apple*

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IN THE fall of 1907 a quantity of Malinda apples topworked upon Oldenburg, was obtained from the orchard of Seth Kenney, at Waterville, Minnesota. These apples were open-pollinated and were taken from a small orchard made up largely of Oldenburg, Wealthy, Scott Winter, Hibernial, English Russet, Patten Greening, Northwestern Greening, and a number of other varieties, most of

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which were topworked on miscellaneous varieties. There were some of the crabs growing near by. It is probable that most of the pollen came from the adjoining trees where crossing took place, although the relative blooming time of the Malinda and other varieties was not recorded. The extent that selfing took place under these conditions cannot, of course, be determined, especially since the status of self-fertility in Malinda in this locality is not known.

There was an unusually high percentage of germination of the seed obtained from this source, and after one year in the seed bed the best seedlings (about 200 of the smaller ones were planted separately the next year) were planted in Plot No. 2, at the Fruit Breeding Farm, $3\frac{1}{2}$ feet apart in rows which were 8 feet apart. This plot has a slight westward slope and a dark, rich, sandy loam soil. Practically every seedling grew. The plot was given clean cultivation up to 2 years ago when grass was allowed to grow.

Two things should be kept in mind with reference to these seedlings (a) all are growing on their own roots and (b) only one parent, the seed parent, is certainly known. Since the time element has brought this plot of 3,879 plants to the final stages of selection and discarding, it is pertinent to raise the question as to what there is of genetic interest to horticulturists in such material.

Open-pollinated seed was selected from Malinda on account of its hardiness and long keeping qualities. It will be recalled that this variety originated in Orange County, Vermont, and was first grown in Minnesota about 1860. The tree is characterized by a scraggly, willowy growth, and tends to form a central stock when not shaped by pruning. The fruit is medium in size, conical, ribbed, firm, fair in quality and keeps in common storage until mid-winter or later. It would appear then that there are some characters in this variety, such as firmness and hardiness, which are desirable and some, as the type of growth and low quality, which are undesirable. The characters then of open-pollinated seedlings, presumably with varieties superior in quality, will be of interest, especially in view of the numbers involved.

THE DISCARDED INFERIOR TYPES

The second and third years after planting in the field plot, the seedlings were carefully inspected and the few which were making a slow growth and the so-called "wild types" were dug out. The number of these in each of the 24 rows of the plot is shown in the first column of Table I.

TABLE I. Showing the record for each row of the trees which have been discarded (a) because of wild type or stunted growth, (b) those which bore inferior fruit, and (c) the remainder, made up of those which have not fruited and those which have been selected for further study or propagation.

Row	Wild types or stunted growth	Inferior fruited types discarded	Trees remaining comprising those selected and those which have not fruited	Total in Row
1	58	53	56	167
2	67	43	47	157
3	72	53	54	179
4	64	53	43	160
5	73	39	55	167
6	60	48	57	165
7	64	48	60	172
8	76	37	52	165
9	77	27	54	158
10	69	33	48	150
11	86	21	47	154
12	69	47	57	173
13	80	28	48	156
14	86	40	57	183
15	75	28	46	149
16	86	24	45	155
17	88	28	53	169
18	74	37	51	162
19	91	29	44	164
20	88	32	51	171
21	89	23	41	153
22	101	18	32	151
23	107	8	35	150
24	103	11	35	149
Total	1903	808	1168	3879
Per cent	49.1	20.8	30.1	

The wild types were thorny, some extremely so, and, while they generally made an average growth compared with the others, some were stunted and scraggly and others were very vigorous. Some of these fruited early and the fruit was generally small, although firm and long keeping. These types, it will be seen from Table I, represented nearly 50 per cent of the whole, or 1903 seedlings out of 3879. While most of these were discarded before fruiting and the type of fruit which would have been borne by the larger number is consequently unknown, there is justification for such heavy discarding on the basis of inconvenience of working trees of this type in either the nursery or the orchard.

VARIATION IN THE TIME OF COMING INTO BEARING

These seedlings have shown great variation in the time of first fruit production. Some fruited as early as the fourth and fifth year after replanting from the seed bed. The sixth year from planting in the orchard, however, the larger portion fruited, and at this time those with inferior fruit were cut out. Following this season (1914), some have fruited each year and further discarding has resulted. It should be mentioned that, while the trees were planted close in the beginning, up to the present the total number discarded repre-

sents approximately 70 per cent of the original number. The space left by the discards has been largely taken up by the increased size of the trees remaining so that where the trees are continuous in the row there is considerable crowding now with the seedlings 11 years in place.

In the early spring of 1915 the larger branches of all remaining trees were either ringed near the trunk or a copper wire wrapped spirally around in an attempt to use this method of forcing them into fruiting. It was especially desirable to bring those which had not as yet fruited into bearing so that further discarding could be done to relieve the crowding. This procedure was of little avail, if any, in inducing fruitfulness.

The number of trees bearing inferior fruit is represented in the second column in Table I and comprises about 20 per cent of the total number. Thirty per cent of the trees are still standing. These are made up of those which have not fruited and those which have been selected for further study or propagation. Since the latter total only about 300 it will be seen that about one-third are left to bear their first fruit. Two past seasons of canker worm injury to foliage, together with further crowding, may result in placing the fruiting time of a considerable number still farther into the future.

The variation shown in the time of coming into fruiting does not appear to be due entirely to crowding since other lots of controlled crosses planted farther apart have shown a similar variation. Furthermore, some trees have shown a tendency to bear a few fruits each year in spite of the close planting. The 300 or so, however, which have been selected to date on account of their promising fruit, present a difficult task in the final weeding out. It will be seen, therefore, that selection can begin early and continue late in such a plot of seedlings. It will be of interest to note whether those trees coming into bearing early as seedlings will also come into bearing early as nursery worked trees, the late bearing habits of some varieties being well known.

SOME OUTSTANDING VARIATIONS IN THE FRUIT

No two of these seedlings have borne fruit exactly alike. Many resemble Malinda, suggesting self-fertilization. Some are sweet and some are sour. Very few, if any, could be ranked with Wealthy or Grimes Golden in quality. In some the long keeping quality, so much sought for in Minnesota, has appeared. The size varies from Wolf River to a small crab. Some have the markings of Wealthy, some of Patten Greening or Northwestern Greening, and some of Hibernial; but most of the selections can be regarded as distinctly new types. A large number of the most promising in external appearance are coarse and only fair in quality. However, among the 300 or so which have been numbered for further study or among those which to date have been sent out to the trial stations for testing, there are a score or so which give promise of being worthy of a place in the variety list of Minnesota. It is too early as yet to speak with any finality of any of these, but there is an interesting list of a few long keeping seedlings of good quality which are variations in the direction sought. These

are as yet, like any new variety, unknown quantities from the standpoint of their commercial value. Since all of the better types will have to be rigidly selected for hardiness, it will be interesting to note the behavior of the seedlings still standing during the test winter of 1917-18.

WINTER INJURY DURING 1917-18

By referring to Table I it will be seen that after discarding the wild types and those producing inferior fruit that 1168 trees remained. This number represents only about 30 per cent of the total, and consequently their relative hardiness can be taken as only partly indicative of hardiness of those discarded. It should be remembered that the 300 or so which have been selected as promising are among them.

TABLE II. A classification of 1168 seedlings of Malinda according to the degree of winter injury in 1917-18. Note the greater injury to the trunk as compared with the top.

Row	Trunk				Main Branches			
	No Injury	Slightly Brown	Medium Brown	Dark Brown	No Injury	Slightly Brown	Medium Brown	Dark Brown
1	9	27	18	2	51	5	—	56
2	5	29	13	—	33	14	—	47
3	19	30	5	—	47	7	—	54
4	24	17	2	—	37	6	—	43
5	18	30	7	—	50	5	—	55
6	16	35	6	—	51	6	—	57
7	13	41	6	—	53	6	1	60
8	18	27	7	—	49	3	—	52
9	10	41	3	—	53	1	—	54
10	4	37	7	—	37	11	—	48
11	4	32	10	1	36	8	3	47
12	8	40	8	1	46	9	2	57
13	10	30	8	—	38	10	—	48
14	10	33	12	2	48	8	1	57
15	6	22	16	2	34	9	3	46
16	5	24	11	5	33	11	1	45
17	5	24	20	4	37	15	1	53
18	3	24	23	1	39	12	—	51
19	3	26	15	—	39	5	—	44
20	3	34	14	—	40	9	2	51
21	—	19	20	2	37	2	1	41
22	—	17	15	—	28	4	—	32
23	2	12	16	5	25	7	3	35
24	—	6	23	6	22	10	3	35
Total	195	657	285	31	963	183	21	1168
Per	16.7	56.2	24.4	2.7	82.4	15.7	1.8	

The degree of browning in the wood in trunk and branch has been taken as the basis of classification. Record was made for each tree by cutting through the bark into the wood with a sharp hatchet about 2 feet above the ground on the trunk, and also on 1 or 2

of the main branches varying from 1 to 1½ inches in diameter. There was generally greater injury on the south side of the trunk than on the north, and in order to emphasize that injury the cut was purposely made on the south side. This appears justified when it is considered that in some there was not even the so-called sun-scald injury present. The larger limbs and branches did not show this difference in browning between the northern and southern sides.

Three things are outstanding in Table II: First, 195 trees out of 1168 escaped injury in 1917-18. Second, there is greater injury generally to the trunk than to the main branches. For instance, note that 963 trees had no browning in the wood of the main branches, while only 195 were uninjured in the trunk and that 657 were slightly injured in the trunk and only 183 were slightly injured in the top. Third, the extent of injury to the trees in each row is fairly consistent.

It would appear that 195 hardy trees out of 1168 is more than would ordinarily be expected, when the severity of the winter of 1917-18 is considered. The question now arises as to how many of these hardy trees have been selected for further study on account of the characteristics of the fruit. Up to 1917, 88 of the trees which had fruited were selected and given numbers. Of these, 22 were hardy in the trunk, 50 were slightly brown, 14 medium brown and 2 dark brown; in the main branches 73 were uninjured and 15 were slightly brown in the wood. These had been selected previous to, and consequently independently of, the killing during winter, and it is encouraging to note that some of the best fruited types are among the hardiest. It is entirely probable, however, that the hardiest seedlings in the plot were among the wild types and those discarded because of the inferior fruit, especially the former.

In view of the extent to which the Malinda seedlings were injured by the winter of 1917-18, the degree of browning in a few of the standard varieties at the Fruit Breeding Farm will be given for comparison. Hibernial and Oldenburg, two of the hardy varieties in Minnesota, were generally hardy in the top, but the wood was often slightly brown in the trunk. *Pyrus baccata* was not injured. Anisim proved to be one of the hardiest varieties, while Wealthy wood was generally slightly, or medium brown. On the other hand, such varieties as Grimes Golden, Black Ben, Delicious, Hubbardston, and Winter Banana were all brown, or dark brown in the wood, even in the smaller limbs. These illustrations taken from the standard varieties only serve to emphasize the hardiness of a large number of the Malinda seedlings.

In a summary statement of the characteristics of these seedlings of Malinda the following may be emphasized: (a) The inferior types can be detected and discarded before fruiting by the appearance of leaf, thorns and branches. In material of this kind this allows for closer planting and consequently the growing of larger numbers. (b) The time of coming into fruiting varies greatly. In these seedlings some fruited at the third and fourth years and a considerable number—approximately one-fifth—have not fruited at the twelfth year. It will be of interest to determine whether the early or late bearing habit as seedlings holds when topworked, or when planted in the

orchard in the usual means. (c) A very small percentage of such seedlings have superior fruit, less than 8 per cent being numbered for study. The long keeping selections of promise do not exceed a dozen. The percentage of superior seedlings may be higher in controlled crosses, but it is probable that with some parents it would not be. (d) There is a great range in hardiness, shown by the degree of browning in the wood. Some of the seedlings are hardier than the standard varieties commonly grown in Minnesota. In fact, from external appearance only a few trees in the entire plot showed injury after the winter of 1917-18. Some of the better fruited seedlings were also among the hardiest. (e) Finally, it should be emphasized again that these seedlings came from open-pollinated seed taken from an orchard in which some of our better varieties were growing. What is the source, then, of so many wild and inferior types? These seedlings, with but very few exceptions, would all come within a single species, *Pyrus malus*. It would appear from this that genetically the best varieties of this species are heterozygous for a large number of characters. Suppose these same varieties are used in making controlled crosses? It would be safe to predict that a comparable number of wild and inferior types would be found among them. From this standpoint it would appear that our named varieties are only rare or extreme variations within the species and that unless certain ones vary in the proportion of inferior types in the progeny, these open pollinated seedlings give a fair index as to the expectations in the F_1 of inter-varietal combinations.

Report of Three Years' Results in Plum Pollination in Oregon*

By ROY E. MARSHALL, *Experiment Station, Blacksburg, Virginia*

In a brief report of this nature, it is only possible to give a general summary of the results. The methods used in collecting, forcing, germinating and applying the pollen, emasculating the flowers and recording the results, were practically the same as those recommended by Fletcher, Sandsten, Lewis, Gardner and Kraus.

A solution of five per cent cane sugar and two per cent gelatin was found to be the most satisfactory media in which to germinate pollen of plum varieties. The germination tests of the pollen of the varieties of *Prunus domestica* showed that the pollen was, generally speaking, satisfactory for use. A comparatively low percentage of the pollen of the varieties of *Prunus triflora* germinated, but it is believed that sufficient pollen of these varieties was used to insure fertilization provided other factors were favorable.

*This work was done by the writer while he was connected with the Oregon Agricultural College.

DETERMINATION OF NORMAL SET OF FRUIT FOR THE PLUM

The results obtained in determining the normal set of fruit under open orchard conditions, indicate that one flower in five should mature a fruit to insure a full crop of the varieties considered. However, there seems to be a great variety variation; some varieties would seem to bear a full crop when only one flower in twenty sets fruit, while in some cases it appears that one of every two or three should mature a fruit.

TO WHAT EXTENT ARE VARIETIES OF PLUMS SELF-FRUITFUL

The term self-fertility has been rather loosely applied in two distinct senses during the past twenty years; one in a wide sense meaning the production of a fruit or fleshy pericarp, which may or may not contain a seed, and in a restricted sense meaning the production of a viable seed. It has recently been proposed that the term suitable for the former class is self-fruitful rather than self-fertile, and that the term self-fertile be restricted to those cases where viable seed is produced. Self-sterile, then, would mean that a variety would not be capable of producing a viable seed when self-pollinated.

TABLE I. RESULTS OF SELF-POLLINATION OF PLUMS

Variety	Location	No. flowers bagged	Per cent mature fruits				Per cent fruits containing normal seeds 1914-1915
			1914	1915*	1916	Ave.	
Bavay	Corvallis	217	0.0	0.0	—	0.0	—
Blue Damson	"	173	42.4	30.0	—	37.5	25.0
Burbank	"	530	0.0	0.0	—	0.0	—
Clyman	"	311	0.0	0.0	—	0.0	—
Giant	"	262	1.7	0.0	—	0.4	0.0
Golden	Riddle	173	5.2	—	—	5.2	100.0
Golden Drop	"	600	0.0	—	—	0.0	—
Golden Drop	Corvallis	1443	—	0.0	0	0.0	—
Green Gage	"	320	2.4	0.0	—	1.9	33.3
Italian	"	2633	3.1	3.0	—	3.1	95.7
Italian	Riddle	684	8.3	—	—	8.3	—
Miracle	Corvallis	231	—	0.0	—	0.0	—
Myrobalan	"	122	—	0.0	—	0.0	—
Peach	"	183	—	0.0	—	0.0	—
Petite	Riddle	623	4.9	—	—	4.9	100.0
Petite	Corvallis	166	—	0.6	—	0.6	—
Pond	"	212	0.0	0.0	—	0.0	—
Pond	Riddle	300	0.0	—	—	0.0	—
Quackenboss	Corvallis	278	0.0	—	—	0.0	—
Red Magnum Bonum	"	385	0.0	0.0	—	0.0	—
Satsuma	"	1122	0.0	0.0	—	0.0	—
Sergeant	"	196	—	0.0	—	0.0	—
Simon	"	321	1.1	0.0	—	0.3	—
Sugar	"	218	2.3	—	—	2.3	80.0
Sultana	"	1110	0.0	0.0	—	0.0	—
Tragedy	"	288	0.0	0.0	—	0.0	—
Wickson	"	554	0.0	0.0	—	0.0	—

*Results of 1915 inconclusive because of hard frost May 1st.

It is readily seen that a variety may be both self-fruitful and self-fertile, or self-fruitful and self-sterile, and these are conditions that actually exist in our pollination work. In case no fruits are produced, the variety may be said to be self-barren.

The results as shown in Table I indicate that of the 23 varieties tested, 13 are self-barren. However, where the results for 1915 alone are given, these should not be interpreted as conclusive because a hard frost on May 1st caused a heavy dropping of fruit. The varieties of *Prunus triflora* are evidently practically self-barren. The European varieties which did not mature fruits were Bavay, Golden Drop, Peach, Pond (Hendrickson found this variety to be self-fruitful), Quackenboss and Red Magnum Bonum. It is probable that if larger numbers of flowers had been sacked for self-pollination and during several years, the results would differ. Golden Drop (Silver Prune) is of chief concern because of its commercial importance in the Pacific Northwest. Observations in orchards of this variety substantiate these results.

Blue Damson is the only decidedly self-fruitful variety in the list, the set resulting in an estimated full crop of fruit. Giant, Golden, Green Gage, Italian, Petite, Simon, and Sugar (later observations have indicated that this tree is Petite rather than Sugar) are partially self-fruitful. The self-pollinated Italian flowers resulted in about 22 per cent of a crop, the Petite about 33 per cent and the Sugar about 10 per cent. The self-pollination work with Italian at Riddle* in 1914 resulted in an estimated crop of 68 per cent.

TO WHAT EXTENT ARE VARIETIES OF *PRUNUS DOMESTICA* INTER-FRUITFUL

The results shown in Table II for 1914 may be regarded as significant for all varieties except Italian. The crop of this variety was much reduced in 1914 by a prolonged period of cold, rainy weather at the zenith of the blooming season. Other varieties bloomed at such times as enabled them to escape serious injury that year. The frost of May 1st, 1915, affected all varieties and a heavy dropping of fruit followed. However, the apparent set, at that time, indicated results similar to those of the other seasons. All factors considered, 1916 was a much more favorable season, but the work was largely confined to crosses in which Italian was either the seed parent or pollen parent.

In view of the results obtained in cross-pollinating varieties of European plums, it seems evident that satisfactory crops should result if any of the common varieties are planted together. There are a few cases where no fruits of the cross matured, but further investigation would probably prove these crosses to be as satisfactory as the average. The variation in the percentage of flowers resulting in mature fruits is probably not greater than might reasonably be expected considering the number of cross-pollinations made and the varied climatic factors of the three years.

Italian set a larger percentage of fruits from self-pollination than

*Work was conducted in a commercial prune orchard at Riddle, Oregon in 1914 as well as at Corvallis.

from cross-pollination in both 1914 and 1915; in fact, Green Gage pollen was the only kind that gave a higher percentage of set than was obtained in a self-pollination or under open field conditions. Both years were unsatisfactory for yields of this variety. In 1916, pollen of Clyman, Pond, Red Magnum Bonum and Tragedy each gave estimated crops of over 100 per cent. Italian pollen has given the highest percentage of mature fruits on all varieties tested except two, and Petite seems to be the second best pollenizer.

Since Golden Drop ranks third in commercial importance in the Pacific Northwest, and is evidently self-barren, the question of a suitable pollenizer arises. Very good results were obtained with all varieties of pollen used; Italian pollen resulted in 200 per cent of an estimated full crop, Petite 250 per cent, Pond 200 per cent, Bavy 190 per cent, and Tragedy 125 per cent. Evidently Golden Drop may be interplanted with Italian, Petite, Pond and possibly other varieties, as it has also given satisfactory results as a pollenizer for these varieties.

TABLE II. RESULTS OF CROSS-POLLINATION WITH VARIETIES OF PRUNUS DOMESTICA

Cross	Location	No pollina- tions made	Per cent mature fruits				Per cent fruits contain- ing nor- mal seeds 1914- 1915
			1914	1915*	1916	Ave.	
Bavay X Italian . . .	Corvallis	400	6.6	0.0	6.5	4.2	33.3
Bradshaw X Italian .	"	108	—	0.0	—	0.0	—
Clyman X Italian . .	"	184	—	—	2.6	2.6	—
German X Italian . .	"	164	—	0.0	—	0.0	—
Giant X Italian	"	491	3.0	8.3	10.0	7.9	41.4
Golden Drop X Bavay	Riddle	129	7.8	—	—	7.8	90.0
" " X Italian	"	202	13.2	—	—	13.2	97.3
" " X Italian	Corvallis	238	—	4.6	—	4.6	—
" " X Petite	Riddle	170	12.3	—	—	12.3	85.7
" " X Petite	Corvallis	235	—	8.9	—	8.9	—
" " X Tragedy	"	137	—	5.1	—	5.1	100.0
" " X Pond	Riddle	96	8.3	—	—	8.3	100.0
Green Gage X Bavay	Corvallis	82	0.0	—	—	0.0	—
" " X Italian	"	191	3.6	—	—	3.6	88.8
" " X Petite	"	140	3.6	—	—	3.6	100.0
Imperial Epineuse X Italian	"	516	5.8	0.0	0.0	1.0	100.0
Imperial Epineuse X Petite	"	26	0.0	0.0	—	0.0	—
Italian X Bavay	Riddle	84	0.0	0.0	—	0.0	—
" X Bavay	Corvallis	403	—	15.1	7.8	11.1	100.0
" X Bradshaw	Riddle	100	0.0	—	—	0.0	—
" X Bradshaw	Corvallis	416	—	0.0	14.6	7.2	—
" X Bulgarian	"	205	0.0	—	—	0.0	—
" X Clyman	"	548	0.0	8.8	25.2	12.3	95.0
" X Clyman	Riddle	116	1.7	—	—	1.7	—
" X German	Corvallis	208	—	0.0	—	0.0	—
" X Giant	"	493	0.0	0.0	10.6	3.2	100.0
" X Giant	Riddle	104	1.9	—	—	1.9	—
" X Golden	"	203	0.0	—	—	0.0	—
" X Golden Drop	Corvallis	635	1.5	3.6	11.0	5.5	100.0

*Results for 1915 inconclusive because of a hard frost on May 1st.

TABLE II—Continued

Cross	Location	No. pollination made	Per cent mature fruits				Per cent fruits containing normal seeds 1914-1915
			1914	1915*	191	Ave.	
Italian X Golden Drop	Riddle	205	0.5	—	—	0.5	—
" X Green Gage	Corvallis	606	4.5	4.4	6.4	5.1	94.4
" X Green Gage	Riddle	196	2.0	—	—	2.0	—
" X Imperial							
" Epineuse . . .	Corvallis	615	0.0	0.8	8.9	3.0	100.0
" X Peach . . .	"	348	0.5	—	8.3	3.7	—
" X Peach . . .	Riddle	188	1.0	—	—	1.0	—
" X Petite . . .	"	209	0.4	—	—	0.4	100.0
" X Petite . . .	Corvallis	976	0.3	2.4	12.3	4.1	—
" X Pond . . .	Corvallis	564	1.1	0.4	25.7	8.5	100.0
" X Pond . . .	Riddle	177	2.2	—	—	2.2	—
" X Quackenboss	Corvallis	211	—	1.4	—	1.4	100.0
" X Red Magnum Bonum	"	568	1.8	3.3	21.8	7.4	100.0
" X Red Magnum Bonum	Riddle	164	3.0	—	—	3.0	—
" X Roberts . . .	Corvallis	250	0.4	—	—	0.4	—
" X Sugar . . .	"	378	0.5	—	7.6	4.0	—
" X Tennant . . .	"	628	1.0	2.4	7.5	3.8	100.0
" X Tragedy . . .	Riddle	237	0.0	—	—	0.0	—
" X Tragedy . . .	Corvallis	391	—	10.0	21.3	14.0	95.2
Peach X Italian . . .	"	304	—	0.0	4.7	2.3	—
Petite X Bavay . . .	Riddle	176	3.9	—	—	3.9	100.0
" X Clyman . . .	"	190	8.4	—	—	8.4	100.0
" X Giant . . .	"	102	6.8	—	—	6.8	75.0
" Golden Drop . . .	"	377	5.5	—	—	5.5	93.7
" X Green Gage . . .	"	139	10.7	—	—	10.7	100.0
" X Imperial							
" Epineuse . . .	"	152	13.1	—	—	13.1	78.0
" X Italian . . .	"	403	7.1	—	—	7.1	100.0
" X Italian . . .	Corvallis	348	—	2.9	4.0	3.4	—
" X Peach . . .	Riddle	170	3.5	—	—	3.5	100.0
" X Pond . . .	"	214	10.7	—	—	10.7	100.0
" X Red Magnum Bonum . . .	"	208	9.6	—	—	9.6	83.3
" X Roberts . . .	"	127	14.1	—	—	14.1	90.9
" X Sugar . . .	Corvallis	157	10.2	—	—	10.2	92.8
" X Tragedy . . .	Riddle	131	11.4	—	—	11.4	100.0
Pond X Giant . . .	Corvallis	100	3.0	—	—	3.0	66.6
" X Golden Drop . . .	"	173	—	0.0	—	0.0	—
" X Golden Drop . . .	Riddle	116	8.6	—	—	8.6	50.0
" X Italian . . .	"	212	18.8	—	—	18.8	32.0
" X Italian . . .	Corvallis	422	—	0.0	8.2	4.0	—
" X Petite . . .	Riddle	109	14.6	—	—	14.6	50.0
Quackenboss X Italian	Corvallis	369	5.0	—	2.0	3.0	11.1
Quackenboss X Petite	"	209	6.7	—	—	6.7	38.8
Red Magnum Bonum							
" X Golden Drop . . .	"	223	5.2	0.0	—	4.3	44.4
Red Magnum Bonum							
" X Italian . . .	"	415	16.0	0.0	5.7	8.1	56.5
Sergeant X Italian . . .	"	177	0.0	—	—	0.0	—
Sugar X Golden Drop . . .	"	193	0.5	—	—	0.5	0.0
" X Italian . . .	"	455	12.3	—	6.3	9.0	96.3
" X Petite . . .	"	201	2.9	—	—	2.9	85.7
Tennant X Golden Drop . . .	"	93	0.0	0.0	—	0.0	—
" X Italian . . .	"	550	12.5	0.0	0.0	4.4	7.6
" X Petite . . .	"	120	0.8	—	—	0.8	85.7
Tragedy X Italian . . .	"	347	17.2	0.0	0.0	6.9	62.5
" X Petite . . .	"	115	1.7	0.0	—	1.7	50.0

*Results for 1915 inconclusive because of a hard frost May 1st.

WHAT RELATION EXISTS BETWEEN FRUITFULNESS AND FERTILITY OF PLUM VARIETIES

A study of the last columns of Tables I and II shows that the varieties of *Prunus domestica* may be divided into two rather distinct groups; one, in which practically every mature fruit contains a normal or apparently viable seed, or, in other words, is fertile to practically the same degree that it is fruitful, and another group in which only a part of the mature fruits contains well developed seeds. Fruits of those varieties in the first group, including Italian, Petite, Golden Drop and Sugar, must evidently contain a viable seed in order to insure complete development of the plum. Apparently, the fruit ceases development and falls to the ground soon after the seed dies or ceases development. It is noticed that from 94 to 100 per cent of the mature Italian, 75 to 100 per cent of the Petite, 85 per cent of the Golden Drop and 80 to 96 per cent of the Sugar fruits, contained well developed seeds.

As further evidence, 131 Italian "drops" were gathered at random in late summer and only 6.1 per cent contained well developed seeds. Again, 269 Italian prunes were purchased at a local grocery store and 98.8 per cent of them contained apparently viable seeds.

In the second group, which contained such varieties as Bavay, Blue Damson, Giant, Green Gage, Pond, Quackenboss, Red Magnum, Bonum, Tennant and Tragedy, the fruits seemed to reach maturity even if the seeds did not continue to full development. The kind of pollen used seems to have had little bearing upon the relationship of fruit production to seed production, as the percentage of seeds developed in any variety seems to be rather constant regardless of the kind of pollen used.

These results indicate that varying degrees of stimulus may be given to the ovule in fertilization, and if that stimulus is not sufficient to push the seed to full development the fruit will drop in certain varieties, while in others the fruit may continue development, provided it has passed a certain state known as the "June drop".

INTER SPECIES POLLINATION

Waugh worked with a number of species of plums and says that although he did not work with the varieties of *Prunus domestica*, there was reliable evidence to show that they could not be effectually pollinated with pollen of Japanese or native varieties. He found most other species inter-fertile.

There are evidently few hybrids containing blood of *Prunus domestica* which is indicative of the difficulty in securing effective inter-species pollination. The hybrids mentioned by Hedrick in *The Plums of New York* are: Alhambra, Burbank No. 7, Burbank No. 11, Miracle, Pennock, Red Glass, Red Glass Junior, Reine des Mirabelles and Victor Sand Cherry. Only 3 contain *Prunus triflora* blood. *Prunus domestica* was evidently not the seed parent in any case.

Table III shows the results of inter-species cross-pollination. Miracle, a hybrid of *Prunus insititia* and *Prunus domestica*, resulted in a few fruits both as a seed and pollen parent. Comparatively

few cross-pollinations were made, but these are enough to indicate that *Prunus domestica* cannot be relied upon to pollinate the self-barren *Prunus triflora* varieties and vice versa. Of the 2,340 pollinations made involving varieties of the 2 species, *Prunus domestica* and *Prunus triflora*, not one fruit resulted.

TABLE III. RESULTS OF INTER-SPECIES POLLINATION WITH PLUMS

Variety Cross	Species Cross	No. pollinations made	Per cent mature fruits			
			1914	1915*	1916	Average
Burbank X Italian	triflora X domestica . .	194	0.0	0	—	0.0
Blue Damson X Imperial Epineuse	insititia X domestica . .	84	0.0	0	—	0.0
Golden Drop X Miracle	domestica X (insititia X domestica) . .	157	—	7	—	7.0
Italian X Blue Damson	domestica X insititia . .	80	—	0	—	0.0
" X Burbank	domestica X triflora . .	155	0.0	—	—	0.0
" X Chalco	domestica X triflora . .	125	—	0	—	0.0
" X Miracle	domestica X (insititia X domestica) . .	751	0.6	0	12.7	4.0
" X ?	domestica X pissardi . .	55	0.0	—	—	0.0
" X Pottawattamie	" X munsoniana . .	67	—	0	—	0.0
" X Satsuma	" triflora	407	0.0	0	—	0.0
" X Simon	" simonii	155	0.0	0	—	0.0
" X Sultana	" triflora	184	0.0	0	—	0.0
" X Wickson	" X (triflora X simonii) . .	117	—	0	—	0.0
" X Wyant	domestica X americana . .	87	—	0	—	0.0
Miracle X Golden Drop	(insititia X domestica X domestica) . .	204	—	0	—	0.0
Miracle X Italian	(insititia X domestica) X domestica . .	380	—	0	0.6	0.3
Myrobalan X Italian	cerasifera X domestica . .	78	—	0	—	0.0
Satsuma X Italian	triflora X domestica . .	380	0.0	0	—	0.0
" X Simon	" X simonii	135	—	0	—	0.0
" X Wickson	" X (triflora X simonii) . .	144	—	0	—	0.0
Simon X Golden Drop	simonii X domestica . .	13	0.0	—	—	0.0
" X Italian	" X	103	—	0	—	0.0
Sultana X Golden Drop	triflora X domestica . .	167	—	0	—	0.0
" X Italian	" X	362	0.0	0	—	0.0
" X Wickson	" X (triflora X simonii) . .	83	—	0	—	0.0
Wickson X Satsuma	(triflora X simonii) X triflora . .	175	—	0	—	0.0
Wickson X Golden Drop	(triflora X simonii) X domestica . .	20	0.0	—	—	0.0

*Results for 1915 inconclusive because of a hard frost on May 1st.

SUMMARY

1. Pollen of the varieties of *Prunus domestica* and *Prunus triflora* seems to germinate best in a solution of 5 per cent cane sugar and 2 per cent gelatin.

2. If there is a normal bloom and 1 flower in 20 matures into a fruit, the result may be a full crop in some cases, while in some others

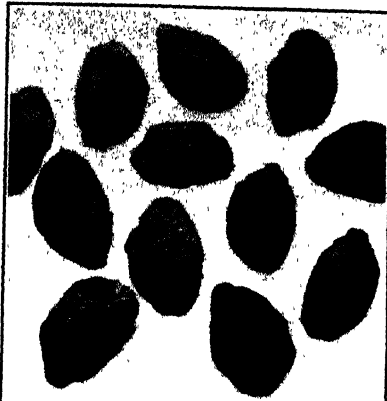


Fig. 1.

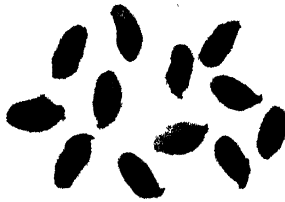


Fig. 2.



Fig. 3.

PLATE I. Used by courtesy of Oregon
Agricultural College Experiment Station



Fig. 4.

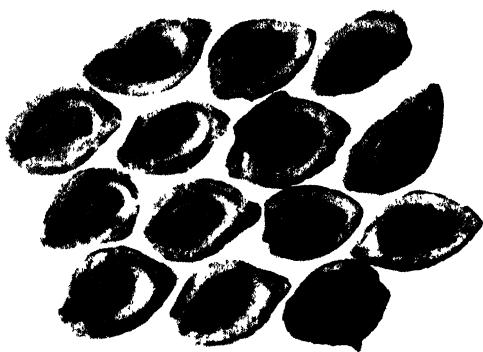


Fig. 5.

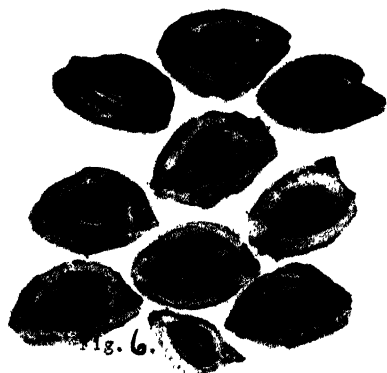


Fig. 6.

PLATE II. Used by courtesy of Oregon
Agricultural College Experiment Station

1 in every 2 or 3 should set to mature a full crop. Generally speaking, 1 flower in 5 should set.

3. Thirteen of the 23 varieties tested are evidently self-barren. Blue Damson is decidedly self-fruitful. Italian and Petite are partially self-fruitful. The other varieties should be considered virtually (commercially) self-barren.

4. The varieties of *Prunus domestica* may be considered as inter-fruitful.

5. Italian and Petite are each good pollenizers for practically all varieties of *Prunus domestica* tested.

6. It is not necessary that one be particular as to which of the varieties of *Prunus domestica* commonly grown in the Pacific Northwest are planted together, provided they bloom at approximately the same time. Some varieties are actually (commercially) profitable where no pollenizers are used.

7. In such varieties as Italian, Petite, Sugar and Golden Drop, the pericarp ceases development soon after the seed dies and the fruit soon falls.

8. In such varieties as Bavay, Blue Damson, Giant, Green Gage, Pond, Quackenboss, Red Magnum Bonum, Tennant and Tragedy, the fruit may mature regardless of complete seed development.

9. For the varieties tested, there is no direct relation between the variety of pollen used and the ratio which exists between plump or well developed seeds and matured fruits. This ratio is fairly constant for the variety regardless of the kind of pollen applied.

10. There is evidently no relation existing between the degree of fruitfulness of reciprocal crosses.

11. The results obtained would indicate that the results are the same whether the varieties of a given species are closely related or non-related.

12. The species of *Prunus domestica* and *Prunus triflora* may be considered inter-sterile for all practical purposes.

EXPLANATION OF PLATES

PLATE I

Fig. 1—Typical Italian "June Drop" picked from the ground beneath a self-pollinated part of an Italian prune tree in August.

Fig. 2—Aborted seeds taken from the Italian "June Drops" shown in figure 4.

Fig. 3—Seeds from mature self-pollinated Italian prunes. Practically every fruit which reached maturity contained an apparently viable seed.

PLATE II

Fig. 4—Seeds from the mature fruits of the Tennant x Italian cross. Only two of the twenty-six fruits which reached maturity contained apparently viable seeds.

Fig. 5—Seeds from the Tragedy x Italian cross. Over sixty per cent of the mature fruits contained apparently normal seeds.

Fig. 6—Seeds from the fruits of the Quackenboss x Petite cross. About forty per cent of these fruits contained well developed seeds.

Inter Species Pollination of Plums

By A. H. HENDRICKSON, *University of California, Berkeley, California*

THE data given in this paper are concerned with the inter-pollination of two varieties of *Prunus domestica*; and one variety each of *Prunus triflora* and *Prunus insititia*. They were obtained during the spring of 1919 in the orchard of the Pomology Department, Cornell University, Ithaca, New York.

During the spring of 1917 the set of Burbank plums (*P. triflora*) in the above orchard seemed to have been aided by the proximity of a row of the Reine Claude (*P. domestica*) variety. According to the observations of Dr. W. H. Chandler, the weather was cold and rainy and decidedly unfavorable for pollination by bees or other insects. At the time of blossoming, however, there was a continuous strong wind blowing from the Reine Claude toward the Burbank. As the season advanced the set of fruit on the Burbank was seen to be heavier on the side of the tree next to the Reine Claude, than on the farther side. This fact at once suggested that one species has been pollinated by the other.

Search through the literature disclosed no convincing data on the subject of inter species pollination of plums. A number of writers, however, have expressed their opinions on the question. Waugh stated that "Triflora plums are readily pollinated by varieties of most any other group. The least affinity seems to exist between them and the Domestica varieties". Fletcher reported that Silver Prunes were aided in setting regular crops by being interplanted with Satsuma, a Japanese variety. No data, however, were given, nor was there any authority quoted for the statement. The same writer reported that the following inter species crosses were successful: Abundance x Grand Duke, Georgeson x Wayland, Satsuma x Golden Drop, Berkman x Golden Drop.

Price in 1905 stated that Domesticas cross with difficulty with other species of this fruit; but that Japanese and native sorts cross-pollinate readily. He gave no data. More recently Marshall in an unpublished paper has presented data to show that domestica and triflora plums tend to be inter-sterile.

The writer while doing graduate work at Cornell University had the opportunity of making a preliminary investigation on the question, using several commercial varieties of plums grown in that section. The weather preceding blossoming was unseasonably cold and on three successive nights late in April the temperature went down to 24°F. The blossoms on most varieties, at that time, were showing white. The amount of frost injury was so great that it was possible to secure sufficient blossoms for experimental work only on four varieties. The varieties used were: Burbank (*P. triflora*), Reine Claude (*P. domestica*), German Prune (*P. domestica*), and Shropshire (*P. insititia*).

The methods of gathering and testing pollen and manipulating the flowers were the same as ordinarily employed by workers on pollination problems. The resulting fruits were counted twice during the season. Only four varieties were used, but the number of blossoms of each was large enough to make the results fairly reliable. The following table gives the results:

TABLE I

Percentage of fruit set under open orchard conditions, when self-pollinated and when cross-pollinated. Cornell University, 1910

Variety and Treatment	Date of emasculation	Date of pollination	No. of blossoms counted	No. of fruits apparently set May 28	Per cent.	No. of blossoms second count	No. of fruits second count June 12	Per cent.
<i>Burbank</i>								
Normal set	—	5-11	2281	115	5.0	2281	28	1.2
x Self	5-6	5-6	150	18	12.0	150	0	0
x Reine Claude	5-4	5-4	316	26	8.2	316	17	5.4
<i>Reine Claude</i>								
Normal set	—	5-13	3505	2116	60.3	3505	249	7.1
x self	5-5	5-5	312	274	87.8	312	40	12.8
x Burbank	5-5	5-8	322	272	84.4	322	2	0.6
x German	5-5	5-6	487	413	84.8	488	66	13.8
<i>German</i>								
Normal set	—	5-13	3298	1675	50.7	3496	701	20.0
x Self	5-8	5-11	426	315	73.9	426	0	0
x Shropshire	5-8	5-11	396	318	80.3	396	117	29.6
x Reine Claude	5-8	5-10	354	272	76.8	354	168	47.4
<i>Shropshire</i>								
Normal set	—	5-13	3591	1714	47.7	3591	211	5.8
x Self	5-8	5-11	599	64	10.6	599	12	2.0
x German	5-7	5-9	433	79	18.2	433	59	13.6
x Reine Claude	5-6	5-9	381	60	15.7	381	46	12.0

The results on the whole were decisive. The varieties were either self-sterile or self-fertile. Except in one case the results of cross pollination were clear cut, and no evidence of inter-sterility between species was found.

Burbank gave a rather low percentage of set when the flowers were left open to insect pollination. This fact may be accounted for by the cold rainy weather which prevailed while this variety was in blossom, and also by the large percentage of injured pistils. When selfed, it proved to be self-sterile. When crossed with Reine Claude, the set was four and one-half times as large as that obtained from insect pollination. Clearly, there was no sterility between European and Japanese species in this particular case.

Reine Claude set 7.1 per cent under open orchard conditions and 12.8 per cent when self-pollinated. Crossed with the Burbank Prune the set was 13.8 per cent. When crossed with the Burbank the set was 0.6 per cent. The low set may have been due to the poor quality of the Burbank pollen used. It was almost impossible during the entire season to secure pollen of this variety of sufficiently high germinating power to justify its use.

German Prune set 20 per cent when pollinated by natural means, but no fruits resulted when self-pollinated. Thus from one year's data it would appear to be self-sterile. Crossed with Reine Claude it set 47.4 per cent. When pollinated with Shropshire (*P. insititia*) the set was 29.6 per cent showing clearly there was no sterility between these two varieties of *P. domestica* and *P. insititia*.

Shropshire Damson set 5.8 per cent when pollinated by natural means, and 2.0 per cent when selfed. Crossed with German Prune the set was 13.6 per cent and with Reine Claude it gave 12 per cent. Clearly no sterility existed between the Shropshire and these two *domestica* varieties.

CONCLUSIONS

Burbank and German gave evidence of being self-sterile.

Reine Claude and Shropshire gave evidence of being self-fertile.

Burbank and Reine Claude are apparently inter-fertile.

Reine Claude, German Prune and Shropshire are likewise inter-fertile.

From these data it is evident that, as far as the varieties tested are concerned, there is no sterility existing between *P. triflora* and *P. domestica* or between *P. domestica* and *P. insititia*.

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Experiences in Plant Hybridization

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EVOOLUTION is no longer a theory, it is an accepted fact. The various modes by which it has proceeded and still is proceeding, are, however, open to debate, and yet pregnant with discoveries for the investigator. Furthermore, we have ceased to look upon evolution of organic beings as merely a curious phenomena, but rather as the chief formative factor in the creation, based on principles that may become of the greatest practical use to us, when properly understood.

After having pondered over the causes of the multiplicity of forms of our domesticated animals and plants for about two generations, we have now come to recognize the fact that man himself has for a

long time unconsciously been a promoter of evolution, as well as its beneficiary.

The principle, that like begets like, with more or less variation, has always been acted upon since man ceased to live as a beast. Up to the time of Darwin, the simple, evident, and every day facts, which have given rise to the idea of evolution, passed unnoticed. The various factors involved in the organic evolution have, however, since that time become a most popular and fascinating subject for study to all naturalists. During a time of barely two generations, Darwin having given the impulse, a huge mass of facts bearing on the evolution has been brought to light; and still the subject seems pregnant with revelations for the investigator.

Of all the fields pertaining to evolution, the one that seems to be the least cultivated is hybridism. This is due to the fact that for a long time, it was looked upon as a factor of lesser importance. In truth, it was thought that hybrids, on an average, fail to produce progeny, or that this progeny through recrossing soon goes back to one of the original parent forms, and thus becomes lost to our observation. Through the more thorough scrutiny of recent years, this has been found to be a misconception. Kermer von Marilaun gives in his work upon "Plant Life" under the chapter "Das Entsehen Neuer Arten" a long list of species, hybrids that behave like true species, many of them occurring in regions where the parent forms are less common than the hybrids themselves, thereby showing that the latter have a different adaptation from that of the former.

In examining the literature on plant genetics, which is altogether a modern science, one is struck by the fact that very few artificially produced hybrids are referred to as examples; that most of those referred to are from natural hybrids; that the various authors on the subject are given to the repetition of identical examples; and that many of these examples are so old as to appear somewhat stale in a modern work. This is undoubtedly due to the fact that there has been a good deal more of writing upon, and interpretation of, old cases, than the production of new ones.

HYBRIDISM IN HORTICULTURE

It is especially in floriculture that hybridism has been employed, and nearly altogether for the purpose of obtaining monstrous novelties. The fact that the floral organs of hybrids were apt to be monstrosities was soon discovered, and so diligently acted on by the florists that nearly all of our most popular ornamental flowers are due to hybridization. We have only to recall the forms of begonia, canna, gladiolus, dianthus, pansies, and a host of others too numerous to mention, many of which come in a large percentage fairly true from seed.

The florists, as a general thing, have produced their hybrids not as students of genetics, but merely for the purpose of the trade, hence they rarely kept records of their procedures, and in many cases the male parent was not even known, being merely due to chance, for which they multiplied the opportunities.

In other lines of horticulture, hybridization has been performed in the same random way. The reason for this is easily found, when we remember that methodical hybridization is slow and very uncertain for the beginner who has to feel his way through, and who is apt to lose time by unforeseen mistakes that cannot be remedied until the recurrence of another season. Hence, years are apt to pass before the hybridizer has received any satisfaction from his work, or pay for it, if he be in need of pay.

With the workers in our experiment stations and agricultural colleges, this encumbrance is absent, since their income does not depend on the immediate proceeds from their experiments. Plant breeding can, therefore, be performed by them both for economic and scientific purposes with much more deliberation and care; and the breeder need not be driven from his work through the lack of his daily bread.

There is no doubt but what the employment of plant breeding is one of the most fertile fields in which the workers of our experiment stations can be engaged. If the evolution of our domesticated plants has proceeded so far under the guidance of an almost unconscious care, what may we not expect when this care becomes both intentional and scientific?

The purposes for which plants may be improved by breeding are infinite in number. New ones are constantly arising, and they differ for the different regions.

PERSONAL EXPERIENCES

My own experiments in hybridization are confined to two genera, namely, *Rubus* and *Quercus*.

The work with the first which has for its object the amelioration of our cultivated blackberries and dewberries as a breeding project under the Adams Fund, was transmitted to me by my predecessor as horticulturist of the Texas Experiment Station. The materials on hand in 1909, when I took charge, consisted of about a dozen varieties of blackberries and dewberries most commonly cultivated in our region. To these I added a few varieties of raspberries for the sake of pollen, although as fruit bearers, they are not dependable upon our grounds.

In looking the material over, I decided to begin the work by crossing those forms that showed the most opposed differences in characters, hoping, thereby, that the elements in the composition of the progeny might be more easily recognized and studied. As a second part of the project, I decided to grow as many seedlings from each variety as possible with a view of studying their variation and the opportunity for selection.

From the McDonald Blackberry, a native of Texas, introduced into cultivation by the Texas Nursery Company, 2,000 seedlings were brought into bearing. This variety has a diffuse, spiny growth, supposed to be a natural hybrid. The 2,000 seedlings fell readily into several more or less distinct groups, one of which was marked by its firm, almost coriaceous, smooth, lustrous leaves of three to five

ovate-lanceolate, nearly entire-margined leaflets. In this group two plants occurred with perfectly smooth shoots, and as free from spines as an ordinary blade of grass. According to the general habit of growth of these two plants they are designated as spineless-diffuse and spineless-erect. From the diffuse form I have grown four generations of seedlings; and though cross-pollination with other forms was provided against, it is only in the first generation that the majority of the progeny in each generation comes spineless and remarkably true to the original sport in all other characters. My notes on the characters of the fourth generation give the following grouping of 200 young plants: 81 perfectly smooth with all characters of original sport; 59 not smooth, with spines more or less evident, but otherwise typical; 60 plants not smooth and of a different type.

The plants of the spineless group were readily recognized in their very early youth by their first leaf-form, which was cordate, or cordate-lanceolate with entire, or crenulate margins, so similar to certain types of violets that, at that age, they might have been passed off on the unsuspecting as violets.

In crossing the spineless-erect with the Early Harvest, two plants were obtained as a first generation. The spineless form in one of these was so dominant that no traces of the Early Harvest, the mother could be detected. The second generation produced under screen by this spineless F_1 generation gave 77 individuals, in which the spineless grandfather was dominant, and 130 in which the Early Harvest, or the grandmother, was dominant. None was absolutely smooth, that is, without pubescence, as in the true spineless type, but the first leaf-form of the 77 was true to that type.

My first attempts at hybridization were, however, directed toward the combination of two forms, that I considered very suitable for my purpose, and from which I hoped for economic results of importance. These were the Early Harvest blackberry and the Austin dewberry.

The Early Harvest, assigned by the systematists to *Rubus argutus* has erect, fluted and sparsely spiny canes, with tri-pinnate leaves, compact and elongated flower clusters with short bracteolate pedicels, and small flowers. The fruit is also small, but one of the sweetest, and the seed the smallest of any of the cultivated blackberries.

The Mays dewberry, also called the Mays Hybrid and Austin-Mays, referred to *R. villosus*, but with considerable doubt, is of a prostrate, diffusely branching growth with terete shoots, sparsely covered with rather small, straight spines. The leaves are three to five foliate; the flowers large, on elongated pedicels aggregated in loose, flat topped, bractless clusters. The fruit is large, due to a few but large drupelets with very large seeds, the flavor is quite sour, and the aroma not perceptible.

From a cross between these two forms, Austin being the mother, I grew to fruiting a F_1 generation of 28 plants. The characters of Austin were so strongly dominant in all of them as almost to exclude all traces of the other parent. All of these plants flowered profusely, and some produced many fruits which, however, were more or less imperfect and irregular in form, due to two kinds of drupelets, small and large intermixed, this being the most evident character of their mixed descent.

An individual in which the characters from both parents were considered to be more evident than in the rest, was selected as mother to a second generation, and, accordingly, screened off from foreign pollination. From the seed of this, a F_2 generation of 425 plants was raised. Of these, 367 were strictly Austin in characters, 37 might be classed as intermediate, and 21 in which the characters of Early Harvest were prevalent. Two of the most typical of the last named form were screened preparatory to mothering a third generation. They flowered profusely, but set no fruit. All other plants of that same generation, exposed to foreign pollen, were more or less sterile, or set imperfect and inferior fruit.

From the reciprocal cross, with Early Harvest as mother, I failed to obtain any progeny; nor did I succeed any better with it as mother, from pollen of other sources. The flowers of Early Harvest are strictly self-fertile and, generally, self-fertilized. What bearing that fact may have on the difficulty of effecting a cross, I do not know.

For some years I made numerous attempts to obtain crosses between various forms of our cultivated blackberries and dewberries, and failures resulted either from perfect or partial sterility; or the hybrids disgusted me because of their confused characters as well as their utter failure to give any promise of improvement for economic purposes. In fact, they all bore the stamp of degenerates in that respect. I will only mention one of these cases, namely a cross between the Mammoth blackberry and the Dallas blackberry.

The first generation consisted of 11 vigorous plants, with the vegetative organs uniformly intermediate of the parents. In the flowers the following anomalies were noticeable: the stamens were much reduced in number and their filaments in length; the disk, upon which the stamens were inserted, had developed into a ring of papilla-like swellings bearing fascicles of pistils replacing a goodly number of the stamens. Such stamens as developed were, however, fertile to considerable degree; since under screen, fairly well developed fruits were obtained. In the second generation this anomaly in the flowers increased, especially in those where the Mammoth characters were dominant. In some the stamens had vanished altogether, and the accessory pistils had become perfect and fertile, developing into druplets of normal appearance when pollenized with pollen from the Loganberry.

From this peculiar fruit, I obtained 39 plants, in which all but one showed the characters of the Loganberry in their early youth; but as they were all lost during the first summer, I missed in this, as in many other cases, the opportunity of further studying them.

I had up to this time made frequent attempts of crossing the blackberries or dewberries with various varieties of the raspberries, but without success until I made use of seedlings of *Rubus rubisetus* as pistil plant.

A quart of fruit of this species was obtained from southern Louisiana in 1910. The seed was sown the same fall and gave rise to a large number of plants quite uniform in general appearance. In 1913, many flowers on various individuals of these seedlings were pollenized with the pollen from the Brilliant and Loudon red raspberries. From

this first combination with the *R. rubisetus* as mother, which for short I shall call the Louisiana dewberry, I raised 21 plants to be transplanted into the open field; and from the other cross with the same mother and Loudon as father, a few less in number.

The characters of the raspberry, *Rubus strigosus*, were strictly dominant in all the individuals of each lot, nor was there any discernible difference in appearance of the two lots. In both, the plants were about equally infertile though nearly all flowered at the proper season. The flowers varied somewhat in size on the various plants, the smallest being slightly larger than the raspberry, and the largest slightly smaller than the Louisiana berry. Whatever fruit set consisted of a few drupelets, irregularly distributed on the receptacle. The color was dark-red to almost brownish-black, when dead-ripe. Cross pollenization was attempted between the various individuals, but did not result in more fruit.

For two years in succession, 1913 and 1914, the seed was sown and a small number of plants as a second generation was raised each year, but no individual arose more fertile or more promising than those of the first generation.

In 1915, the crop of fruit from this first generation was a little more abundant and gave rise to 280 plants, of which 125 reached bearing age in 1917. But, as the mother plants of the first generation were not screened from foreign pollenation during flowering time that spring, the true origin of these plants was in doubt. Upon reaching maturity, I estimated them to fall into the following groups: 28 per cent raspberry dominant; 41 per cent Louisiana berry dominant; 22 per cent, intermediate; and 3 per cent, indefinable.

The group in which the raspberry was dominant might again be divided according to vigor into two extremes, very strong and very weak, with intermediates tending to either extreme. The next thing that caught my eyes was that, in the most robust group of the raspberry-dominants, there were 5 plants setting perfect fruits and promising a good crop on each plant.

These five plants differ from each other in no other feature, except that one, which I named the First Choice, was of a greater size, and, on that account bore a larger crop of fruit. They were all coarse raspberry forms with heavy ascending or prostrate, terete canes, beset with numerous weak, short prickles. The leaves were very large, of raspberry texture with 3 to 5 broadly ovate to rotund, coarsely serrate leaflets. The flowers were intermediate in size between those of the original parents, and borne on elongated pedicels in clusters similar to those of the Louisiana berry. The fruit, at maturity, was dark cherry-red to brownish-black, when overripe. The size of it was much larger than that of either of the original parents; in fact, larger than any Loganberry produced on our grounds. The flavor was mildly acid with a strong reminder of the raspberry.

Two plantings of this third generation are now growing on our grounds; one, made in the spring of 1918 from seed produced in the open, the other, planted in the field last spring, from seed produced under screen. The first consists of about 900 plants which fruited this year. In general appearance, these vary no more from each

other or from their mother-plants in the second generation, than may be expected from descendants of what, in nature, is recognized as a true species. The variations, such as they are, consist mostly in rankness and direction of the shoots, size of the leaves, size and abundance of the fruit, as well as the time and length of the fruiting period. The general type and characters of their various organs are the same.

According to these variations, I eliminated from time to time during the season all but 4, among which I am as yet undecided as to the preference.

As to flavor, form, or color of fruit, no positive distinction could be made. The fruit differs from both the blackberry and the raspberry in the mode of disjoining from the pedicel, in-as-much as that takes place at the base of the calyx which is attached to the fruit. Because of this, the picking of the berries is a little difficult, since there is not a well defined node where the disjoining takes place. No positive variation in this character has given opportunity for selection.

The four plants of the third generation, finally selected as elites, produced fruit from the middle of May to the middle of August; hence the length of the fruiting season during the past summer was about three months. Another noticeable character was that the fruit did not perceptibly deteriorate in size or flavor as the season advanced. The later part of the crop was produced on shoots of the current season. This character, which results in a long season of bearing, is evidently inherited, in a great measure, from *Rubus rubisetus*, where this tendency is present, but less evident.

The most remarkable part of these phenomena appears to me to be that fertility appeared only in the most robust group of those of the F_2 generation, in which the raspberry was dominant; and, that having once occurred, it became invariably hereditary, just as though sterility was merely a passing crisis.

Self-pollination, both in the five plants of the second generation, and in their descendants of the third, took place to perfection under screen; and their pollen, when used in crossing some even distantly related forms, gave rise to apparently good seed. I have also crossed both the second and the third generation with foreign pollen with excellent results. With the second generation plants as mothers, and McDonald Spineless-diffuse as father, I have 3 thrifty hybrid plants one year old. With another form as mother, namely, Haymaker x Louisiana F_1 , which in itself is very sterile, I have 6 very thrifty plants from last year's seed. The formula of this combination is, therefore (Haymaker x Louisiana) F_1 X (Brilliant x Louisiana) F_2 .

From the third generation, as mothers, and Early Harvest blackberry, as father, I have sown enough seed this fall to permit the hope of an ample start.

Beside these, I have tried the pollen of the third generation on other crosses with surprisingly good results, so far as setting of fruit and production of seed are concerned. In short, the ease with which these plants lend themselves to hybridization with other forms astonished me, when I remember my previous difficulties and failures with some of their congeners.

As regards hardiness, both the second and the third generations have made ample tests on our ground and passed them without the slightest signs of discomfort. The drought and high temperature of summer before last was the severest in memory of even the oldest inhabitant, yet no individual in the entire third generation of more than 900 plants showed the slightest distress. This last summer has become famed for the opposite extreme, yet no deaths, or even diseases, have occurred among these plants.

OAK HYBRIDS

Concerning the work with oaks, I shall be brief, because the principal part of my experiences were published in the October issue of the *Journal of Heredity* in 1918.

From 6 out of the 7 specimens of the first generation of *Quercus lyrata* x *Virginiana*, described in that article, I have the following individual trees of a second generation; 1, 3 years old; 12, 2 years old; and 9, 1 year old. All of these are due to a second hybridization, since none of the first generation produced pollen until this last spring. The 12 trees 2 years old, having reached a greater development, show the greater diversity in form. But in only 2 individuals of these can the immediate father be identified from its dominancy in the progeny; namely in 1, in which the Live Oak seems to have furnished the pollen, and another, in which the Post Oak is so dominant as to exclude all traces of the other two species.

The only specimen of the first generation that has produced no fruit, bore this spring an abundance of male flowers with apparently potent pollen. A sister tree in very close proximity to this matured as a consequence, presumably, a much larger crop of acorns than any of the others. These acorns have been planted, and some have at this writing (November 28) made healthy-looking shoots.

Besides the above hybrids of the first and the second generation of *Q. lyrata* x *Q. Virginiana*, I have 3 handsome specimens of *Q. bicolor* x *Q. Virginiana* F₁, 1 year old. The leaves of these are much larger than in the *lyrata-Virginiana* cross, but apparently of similar texture and persistency. The outline and venation of the leaves strongly remind one of *Q. prinus*, since the dentations in the margins are finer and more regular than in the male parent.

Besides the seed from the fourth crop for a new second generation of *Q. lyrata* x *Q. Virginiana*, I have, this fall, also planted several acorns due to cross-pollination of last spring between the Post Oak and the Live Oak, and Water Oak and Live Oak. Some in both of these lots have already germinated and are making promising shoots.

From the work with the oaks, I have learned that the various individuals of a species vary widely in their affinity for foreign pollen. For several seasons I wasted my time with a Live Oak which I selected for mother, because of its bearing qualities and the convenient locality, in which it grew. I employed the greatest care in pollenizing a large number of pistils, using for the experiment pollen from 4 different species, but without results. Owing to previous experiences, I commence to doubt the fitness of this tree as mother for hybrids,

and accordingly made a comparative test by dividing the pollen with other individuals. The proof of difference in the affinity for foreign pollen was beyond doubt. One tree producing rather small and irregularly sized acorns, such as I, under different circumstances, would have avoided, proved the surest mother to hybrids.

After that experience I have come to believe that to be successful in hybridization, it is necessary to search out by trial the individuals having the proper affinity for the pollen to be applied. For this purpose, seedlings would naturally be preferred to plants produced vegetatively.

The Apple Cross—Tolman X Malus Toringo

By C. S. CRANDALL, *University of Illinois, Urbana, Illinois*

THE group of apple seedlings to be considered in this paper is the product of what deserves to be called a violent cross, that is to say, the two parent plants are as widely different as seems possible and still include them within the limits of the genus *Malus*. In this cross, Tolman a well known standard variety, served as the pistillate parent and a dwarf form of *Malus Toringo* as the pollen parent.

THE PARENT TREES

Tolman: Tree 9, row 11, Plat "A"—Tree 25 years old, vigorous, healthy, wide-spreading; crown symmetrically developed, top open, lower branches somewhat drooping; twigs heavily pubescent. Bark of trunk dark grayish; of twigs, dark chocolate-brown. Lenticels few, mostly small, round, light brown. Tree bears regularly.

Malus Toringo dwarf form (No. 852)—Tree 17, row 15, Plat "I". Top-graft inserted on Virginia crab seedling April 9, 1908. Flowering for the first time in 1911. Tree form may be taken from a tree root-grafted on ordinary apple seedling stock in January 1908 and now 12 years old. Height 8 feet, 2 inches, spread 10 feet, 4 inches, diameter of trunk 4 inches. Branches numerous, more or less contorted, upper, in general, horizontal, lower sweeping to the ground. Trunk crooked with very rough, dark reddish-brown bark. Twigs with numerous irregular longitudinal ridges; bark bright reddish-brown, smooth, lightly pubescent in spring and summer, becoming nearly glabrous in winter. Lenticels few, mostly small, round, occasionally somewhat elongated longitudinally, light brown.

LEAVES

Tolman—Leaves dark green above, lighter green below; dimensions as determined from measurement of 100 leaves as follows: length varies between 28 and 116 mm. (1.1 and 4.57 inches) with an average of 86.2 mm. (3.39 inches); width varies between 15 and 56 mm. (0.59 and 2.2 inches) with an average of 36.2 mm. (1.42 inches);

elliptical, oblong or oval; tip is acuminate in 31, acute in 42 and obtuse in 27; 95 are bluntly serrate and 5 crenate; none are lobed; glabrous above except directly on the midrib, closely and finely tomentose below.

Petioles vary in length from 12 to 43 mm. (.47 to 1.69 inches) with an average of 23.3 mm. (.92 inches); rather stout, pubescent; stipules lanceolate 6 to 12 mm. long, persisting on some leaves.

Malus Toringo—Leaves small; the extremes of length in 100 leaves are 25 mm. for the shortest and 57 mm. for the longest (1 to 2.24 inches) with an average of 44.9 mm. (1.77 inches); in width they vary between 13 and 33 mm. (.51 and 1.3 inches), with an average of 25.8 mm. (1.02 inches); those on sterile shoots ovate in outline, 3-lobed, the larger central lobe often variously incised; on fruiting shoots and spurs mostly lanceolate. Larger leaves mostly rounded at base, smaller more or less cuneate; of the 100 leaves 62 are acuminate, 35 acute and 3 obtuse; margins are, in all leaves, crenate-serrate; some of the smaller leaves are entire below and crenate-serrate above. Leaves on sterile shoots more or less recurved and folded longitudinally. Petioles vary in length from 7 to 17 mm. (.27 to .67 inch), slender, pubescent. All leaves are dark gray-green above, lighter below; glabrous above, slightly pubescent below, densely so along the midrib. Stipules 6 to 12 mm. ($\frac{1}{4}$ to $\frac{1}{2}$ inch) long, lanceolate, often with 1 to 3 teeth on the margin; mostly falling early.

FLOWERING OF TREES

Both Tolman and *Malus Toringo* flower from terminal and lateral buds of terminal shoots and from terminal buds of spurs, but with Tolman the production of flowers from lateral buds of terminal shoots is much less common than with *Malus Toringo*. Usually all buds for from 6 to 12 or more inches from the distal ends of *Malus Toringo* shoots are flower buds and, at flowering time, the color is massed in great bunches that are decidedly ornamental.

FLOWERS

The flower buds of Tolman are of medium size, globular, light pink; those of *Malus Toringo*, small, globular, deep red. The Tolman flower expands 35 to 37 mm.; that of *Malus Toringo* 16 to 20 mm. Pedicels of Tolman are 20 to 24 mm. in length, stout, bracteate, densely pubescent; those of *Malus Toringo* 18 to 20 mm. in length, very slender, ebracteate, scantily pubescent, often glabrous except towards the base. Expanded petals of Tolman ovate, rounded, at apex, 19 mm. long by 12 mm. wide, pure white, claw distinct 1 mm. long; petals of *Malus Toringo* oval or oblong, rounded at apex 8 mm. long by 5 mm. wide, claw short; white with light pink tinge. Stamens of Tolman 15 to 18, filaments slender 5 to 8 mm. long; anthers plump, light yellow. Stamens of *Malus Toringo* 7 to 21, the average number as determined from 189 flowers in 16.75; filaments slender, 3 to 5 mm. long, anthers plump, medium yellow, several shades darker than anthers of Tolman. Style of Tolman 5, slender,

9 to 19 mm. long, connate $\frac{1}{3}$ to $\frac{1}{2}$ the length, glabrous at base, hairy in a broad belt covering the point of separation.

Ovary in Tolman flowers green, densely white tomentose; in *Malus Toringo* flowers red in color, wholly glabrous. Calyx lobes of Tolman flowers large, acuminate, pubescent both sides; those of *Malus Toringo* more slender, the acumination more attenuate, pubescent on the inside only.

FRUIT

Tolman—Medium or below in size, uniform, roundish or somewhat oblate. The average of 200 fruits examined in detail had a vertical diameter of 59 mm., a transverse diameter of 69 mm. and weighed 121.16 grams; sides equal, sometimes obscurely ribbed; clear pale yellow or yellowish-green, rarely with a slight blush; bloom fairly abundant, grayish-white. Skin rather thick, tough, smooth. Dots many, small, round, white or yellowish, scattered, inconspicuous. Cavity deep, broad, obtuse or acute, irregularly ridged, somewhat russeted. Stem medium to long, slender, green or brownish, pubescent. Basin shallow to moderately deep, of medium width, irregular, wrinkled. Calyx closed to partly open, medium to small, heavily pubescent. Calyx lobes large, long-acuminate, tips commonly reflexed. Calyx tube of medium length, rather wide, urn-shaped. Stamens median, pistil point present. Core closed, rather small, median, cordate, core lines clasping. Cells closed. Carpels broadly roundish, apex emarginate, tufted, rather flat. Flesh white, firm, rather dry, sweet, good. Average number of good seeds 8.14. Of the 200 fruits 196 had 5 carpels each and 4 had 6 each.

Malus Toringo—Fruit very small. The average of 100 fruits had a vertical diameter of 7 mm., a transverse diameter of 9 mm. and weighed 0.38 grams. The form was roundish-oblate with truncate apex; base regular, flat, cross section regular. Uniformly pale orange-yellow; no bloom, skin smooth, polished, tough, thin; dots not apparent. Cavity very shallow, sometimes none, regular. Basin none, apex surmounted by the large, circular, russet scar left by the deciduous calyx lobes which fall off early in the development of the fruit. The calyx tube forms a small conical depression at the center of the scar. Core large in proportion to size of fruit, oblate median, closed; cells axile, oblate, variable. Carpels obovate, emarginate, glabrous, concave. Seeds very small, light in color. Flesh yellowish, acid, astringent. Of 100 fruits 12 had 3 carpels each 71 had 4 each and 17 had 5 each. The average seed content was 3.42.

THE CROSS—TOLMAN X TORINGO

Two buds in each of 25 Tolman flower clusters were emasculated May 8, 1911. Pollen of *Malus Toringo* was applied to the Tolman stigmas May 11. Ten fruits in seven clusters developed, were picked and described October 25. The average weight of these fruits was 70.25 grams; vertical diameters ranged from 37.5 mm. to 45 mm. with an average of 42.2 mm.; transverse diameters from 46 mm. to 58.5 mm. with an average of 53.9 mm. Seeds ranged from 3 to 9 in

each fruit and aggregated 59 from the ten fruits. Seeds stratified November 7 and placed outside for the winter. March 29, 1912, the seeds were brought in and 58 were planted singly in dirt bands in flats. The seeds germinated numbered 46 or 79.31 per cent of those planted.

Two seedlings died shortly after germination; the remaining 44 were planted in nursery May 17. Five died during the first year in nursery. In November, 39 seedlings were lifted and stored for the winter, May 9, 1913, the seedlings were again planted in nursery. Three died during the second year. In November the remaining 36 were taken up for storage. April 16, 1914, two seedlings were found dead, leaving 34 which were planted in orchard as trees 17 to 50 in row 33 of the Douglas tract.

Five trees died during this first year in orchard so that when the growth record was taken in October, 1914, there were living 29 of the original 46 seedlings or 63.04 per cent. One tree has died since as a result of flooding and imperfect drainage. Thus there remain, at the end of the eighth year, 28 of the original 46 trees or 60.87 per cent.

These trees range in height from 5 feet 4 inches to 12 feet 9 inches with an average of 10 feet 4 inches; in spread from 6 feet 2 inches to 14 feet 7 inches, with an average of 10 feet 9 inches. The range in trunk diameters is from 2.1 inches to 4.3 inches with an average of 3.51 inches. When rated as to quality, at the end of the first year in orchard, none classed as "good", 19 were rated "fair" and 9 as "poor". At the end of the sixth year in orchard they stand as 25 "good", 1 "fair" and 2 "poor".

While there are well marked individual differences the trees show a general tendency to form rounded symmetrical crowns. Branches are, at first, ascending, later the lower become horizontal and finally drooping. Shoots of the current year are numerous, strictly erect, from 18 inches to over four feet in length.

In general appearance the trees strongly resemble the male parent, except that they are not dwarf in habit and greatly exceed *Malus Toringo* in vigor of growth. The color of bark of trunk and branches is brighter than in either parent, but accentuates the red color of *Malus Toringo* bark and retains faintly the striations of shoots of that species. Foliage on all trees is dense, the leaves very variable in size, but averaging larger than the leaves on either parent. The average length of 100 leaves is 93.5 mm. as compared with 86.24 mm. as the average length of Tolman leaves and 44.88 mm. as the average length of leaves of *Malus Toringo*; the average width of leaves of hybrid seedlings is 39.76 mm., while for Tolman the average width is 36.22 mm. and for *Malus Toringo* 25.8 mm.

Lobed leaves are found on 18 trees, but on most of them are only occasional. Leaves on remaining trees do not exhibit the slightest tendency to lobing. On all trees the leaves are flat, with none of the recurving so strongly marked in leaves of *Malus Toringo*. All leaves are very dark green, much darker than are Tolman leaves, and without the gray appearance characteristic of leaves of *Malus Toringo*.

In 1916 one tree, then four years old, produced a single flower cluster, but no fruits. In 1917 two trees produced each a single flower cluster; these flowers were emasculated and on April 14 pollinated with Tolman pollen; the pollinations on one tree failed, from those on the other three fruits matured. In 1918 twelve trees flowered sparingly and 168 buds on seven trees were emasculated and later pollinated with Tolman pollen. Exactly 50 per cent of the pollinations were successful and 84 fruits were matured from six trees. In the spring of 1919 all but four of the trees produced flowers in varying quantity, some only a few clusters, others nearly a normal full bloom.

A prearranged plan of pollination was rendered useless by a frost April 25. It was thought at the time that destruction of the flowers was complete, but some of the trees matured each a few fruits; no pollinating, however, was done.

There are now on file flower and fruit descriptions from 22 of the 28 trees. Six trees have not yet produced fruits.

All trees that have flowered sufficiently show the tendency of the male parent to mass flowers, at the ends of terminal shoots, by production from lateral buds. Flower buds appear exactly like those of *Malus Toringo* except for a slight increase in size; they are globular and very dark red. Expanded flowers are exactly intermediate in size between those of the two parents; they are pure white, as are flowers of Tolman, showing no pink tinge as is common in flowers of *Malus Toringo*. Pedicels are twice as long as in either parent, intermediate in thickness, but appearing very slender because of their length; as to pubescence they are intermediate, having less than pedicels of Tolman and rather more than those of *Malus Toringo*. The ovaries in Tolman flowers are densely pubescent, in *Malus Toringo* entirely glabrous and red in color, in the hybrids they are sometimes glabrous, sometimes covered with scattered white hairs and are usually more or less colored red. Calyx lobes of flowers of the seedlings are larger than those of flowers of *Malus Toringo*, but have the same long narrow acumination. While calyx lobes are pubescent both sides in Tolman, and on the inside only in *Malus Toringo*, both these arrangements appear in the hybrids, but in the flowers of the hybrids the pubescence of calyx lobes is very much less dense than is the case with lobes of Tolman flowers. Petals of hybrid flowers are intermediate in size between those of flowers of the parent plants, but, in general, are narrower than those of Tolman flowers and nearer the form of *Malus Toringo* petals.

Stamens have the same range in numbers in flowers of Tolman and in flowers of the hybrids, namely 15 to 18; in *Malus Toringo* flowers the range in numbers is from 7 to 21. Tolman filaments are more robust than are those of *Malus Toringo*, and, in the hybrids they are intermediate. Styles in Tolman flowers are 4 or 5, mostly 5; in *Malus Toringo* flowers they are 2 to 5, mostly 4; in the hybrids they are either 4 or 5, one number as common as the other. The degree of connation of the styles is about the same for both parents and for the hybrids.

HYBRID FRUITS

Fruits of the 22 hybrid seedlings that have borne do not bear any close resemblance to those of either parent; they appear as small apples, or small crabs, and there is remarkable uniformity in form, size and color of fruits from the different trees. Fruits are intermediate in size, but much nearer the size of *Malus Toringo* fruits than they are those of Tolman. The average of 200 Tolman fruits is over 22 times the weight of the average hybrid fruit, while the average hybrid fruit is only 14.25 times the weight of the average fruit of *Malus Toringo*. The average of all hybrid fruits weighs 5.42 grams, has a vertical diameter of 19 mm. and a transverse diameter of 22 mm.

The color is a uniform yellow, but not the yellow of either Tolman or *Malus Toringo*; it may be described as a dark dull orange.

Calyx lobes are wholly deciduous in fruits from two trees, wholly persistent in fruits from one tree and variously divided in fruits from the other 19 trees; from four of these above 50 per cent of the fruits have deciduous lobes and from 15 trees above 50 per cent have persistent lobes. Fruits having persistent calyx lobes have no basin, the apex is, in each fruit, rounded up to the fleshy bases of the lobes.

From study of the progeny of this cross between Tolman and *Malus Toringo* it must be concluded that some, at least, of the characters combined, appear in the progeny as intermediates, meaning by intermediate that they are between those of the two parents as extremes, but by no means occupying a central position. In habit the trees do not suggest Tolman, although tending to form rounded tops; they differ from *Malus Toringo* in being less dwarf and of more vigorous growth. Bark color and appearance are wholly like that of the male parent and in no particular resembling Tolman. Foliage of hybrid trees is more dense than is the foliage of either parent, but its general appearance suggests neither Tolman nor *Malus Toringo*; it is darker than Tolman foliage, has not the gray tinge of *Malus Toringo* foliage, and the individual leaves are flat with no tendency to recurving. Leaves are, in part, lobed as in *Malus Toringo*, but the lobing is much reduced and, on most trees, inconspicuous. Petioles of leaves of Tolman and of those of *Malus Toringo* are of about the same length; leaves of hybrid trees have much longer petioles, averaging double the length of petioles of leaves of parents. Flower expansion is intermediate, the flowers of hybrids standing almost exactly midway, in spread, between those of the two parents. Pedicels are, however, unlike either those of Tolman or those of *Malus Toringo*, being, as in the case of leaf petioles, very nearly twice as long as in either. Flower buds in the hybrids are exactly like those of the male parent in color and form, but are slightly larger; in anthesis the petals fade to pure white as in Tolman.

Except that the fruits of the hybrid trees are plainly apples, they bear no resemblance to those of either parent; they are intermediate in size, but to occupy a median position would have to be many times heavier and have the diameters more than doubled.

The outstanding fact regarding this group of seedlings is the extent of the domination of the dwarf, small-fruited male parent and the corresponding suppression of resemblance to the mother plant. While the hybrid trees have their individual differences they all exhibit a uniform resemblance to *Malus Toringo*; they are *Malus Toringo* trees invigorated, smoothed out and improved. Those characters that occupy intermediate positions between the parents are not median, except as to flower expansion, but are much nearer the male than the female parent.

This dominance of *Malus Toringo* characters is indicative of a degree of stability and fixity only acquired by existence through many generations and we must assume this plant to be a true species and very near if not identical with the wild type.

Results of Bud Selection Investigations at the Missouri and Oregon Experiment Stations and Their Interpretation

By V. R. GARDNER, *University of Missouri, Columbia, Missouri*

THE question of bud variation and bud selection is one that has been prominent in the horticultural literature of the past half century, and it has been particularly prominent during the past decade. It is not necessary at this time to review that literature, for those in attendance at this meeting are well acquainted with it. You know about the great diversity of opinions that are held and the nature of the evidence that has been presented to support them. Consequently this paper will be limited to a very brief summary of recent work along this line by the Missouri and Oregon Stations with which the writer has been connected.

Bud selection work at the Missouri Station was begun in 1895 when scions were taken from two Ben Davis trees. One of these two trees had been a heavy and regular producer of high grade fruit; the other a light producer of fruit inferior in size and color. There was nothing about the appearance or environment of the trees to suggest that their behavior was due to anything other than internal causes. Thus it seemed that they furnished exceptionally good material for starting a bud-selection experiment to test the transmissibility of individual variations in productiveness. Resulting trees from the scions taken in 1895 were grown under uniform conditions. The 1912-1919 crops were measured accurately and the records furnish exact information on the effects of this particular bud selection. The results of this particular experiment may be summarized by stating that the trees propagated from the poor parent were equal to those propagated from the good parent in productiveness, regularity of bearing and grade of fruit produced.

A little later a similar experiment was begun with strawberries by the Missouri Station. Runners were taken from the six most

productive and from the six least productive individuals in the Station's plot of a standard variety. When these daughter plants came into bearing proper records were taken and selections again made from the most productive and least productive individuals. This work was continued until ten successive generations and been grown and fruited, there being ten successive plus selections and as many successive minus selections. Throughout the experiment the plus selections proved to be no more productive than the corresponding minus selections. Furthermore there was as much variation within each of the selected strains resulting from the selection as there was in the entire stock to begin with. Nothing had been gained, or lost, by the work of selection.

In 1913, plus and minus selections were made of four varieties of strawberries that were on trial on the grounds of the Oregon Station. The daughter plants were fruited first in 1915 and for three succeeding seasons. The results attending these selections, at least so far as yield is concerned, were practically identical with those obtained by the Missouri Station. It is worthy of note, however, that the mother plant of the Wilson selected for its extremely low yield was also a very poor runner producer (producing only six runners the first season), while the high yielding Wilson plant was a heavy runner producer (producing over 50 daughter plants); and that the daughter plants of these two selections exhibited the same characteristics of light and heavy runner production, respectively, throughout their life. At the same time that plus and minus selections were made at the Oregon Station of several standard varieties, selections were made of productive and barren daughter plants of two seedlings originating on the Station grounds. The subsequent record of the daughter plants of one of these two selections was similar to that of the selected plants of the standard varieties; but the subsequent record of the daughter plants of the other selection was different. The daughter plants of the high yielding parent showed a fairly wide range in yield, but they had a normal average. On the other hand the daughter plants of the barren parent, though not entirely barren, were low in yield, not over half the normal yield for the entire stock of this variety. Furthermore these two lots of daughter plants continued to give high and low yields respectively for three successive seasons. Here, then, was a clear-cut instance of the isolation of a strain of strawberries (in this case inferior to the normal) through bud selection. It is interesting to note in passing that the variation from the normal that in this case could be perpetuated, was in the direction of deterioration or degeneration. From a *practical* viewpoint, all bud selection could accomplish would be to keep the variety up to its own standard by the weeding-out of an infertile or semi-barren strain.

THE DEGENERATION OF STRAWBERRY VARIETIES THROUGH BUD-VARIATION

Station investigators and growers as well often have noticed that individual plants in a row of strawberries would become weak and die out because of a lack of vigor when other plants of the same

varieties along side them would remain strong, vigorous and productive. This has been attributed to insect or disease attack, unfavorable soil, or to other local environment causes, or to accident, and apparently little special attention has been given to the matter. The behavior of some of the seedling strawberry plants, or, more accurately, runner-propagated daughter plants of some of the seedlings, growing upon the grounds of the Oregon Station challenged attention in this connection. The matter can be presented best by brief notes on the observations made upon several of these forms.

Station Seedling 901 (a Glen Mary x Clark cross)—First fruited in 1913. Very productive and regarded promising. Its 48 daughter plants were set out in the Spring of 1914. No fruit borne in 1915 on account of frost. In 1916 the plants were uniformly strong and vigorous, but without exception they produced very few berries. In 1917 they were still uniformly vigorous but also uniformly unproductive. The whole stock of the variety had suddenly deteriorated in-so-far as fruit production was concerned.

Station Seedling 1100 (a Marshall x Clark cross)—First fruited in 1913. Very productive, vigorous, and regarded as promising. Its 94 daughter plants were all set in the Spring of 1914. They grew well during 1914 and in the autumn of that season presented a fairly uniform appearance. In 1915 they bore practically no fruit on account of frost and consequently were able to turn practically all their energies into vegetative growth. All runners were removed promptly and consequently vegetative growth meant in this case roots, crowns and leaves. During this season, however, many plants showed marked vegetative deterioration, though other plants alternating with them in the row retained normal vigor. In 1916 the plants of normal vigor bore normal crops, though the row as a whole bore a light crop on account of the deterioration of so many individuals. In the spring of 1917, 16 plants were still strong and vigorous, 47 were weak and degenerate, and 31 had died, apparently from lack of vigor. Runners were obtained from the normal individuals and also from the degenerate plants and set side by side in a new location. Most of the daughters of the degenerate plants died the first year, though a few survived. None were normally vigorous. On the other hand the daughters of the vigorous mother plants made a normal, vigorous growth. Here is a case of a comparatively large percentage of the stock of a variety more or less suddenly deteriorating and the deteriorated strain then perpetuating itself by means of runners.

Station Seedling 1202—Without going into detail regarding the behavior of this plant it may be stated that the original seedling was very vigorous, productive and promising. Its daughter plants made uniform, fairly vigorous growth the first season, and then gradually lost their vigor. By the end of the second season they were all very weak and would have been classed by a commercial grower as "run-out" worthless stock. Nearly all the plants survived the following two seasons, but remained weak and produced only a few small berries. Runners taken from these degenerate plants and set in a new location, made a growth the first season that would

be classed as medium to weak in character. However, these same plants gradually regained vigor during the two following seasons and in 1918 yielded at the rate of 122 crates per acre, a good yield for such an unfavorable season. Ordinarily when the entire stock of a variety is modified in one direction in this way the change is looked upon as accommodative or adaptive and some feature of environment is regarded as its cause. The change, however, in both kind and direction corresponded to that in Station Seedling No. 1190 where only a part of the stock was affected, and hence where it may be classed as a bud variation. The fact that plants of a number of other varieties under the same conditions showed no tendency to undergo such changes, but continued normal in both vegetative and fruiting characters, affords added evidence for the belief that the variation was due primarily to internal, rather than external, factors.

BUD VARIATION ASSOCIATED WITH PARENTAL CHARACTERISTICS

Incidental to the breeding work at the Oregon Station some crosses were made between a wild form of *F. chiloensis* and a cultivated variety. The wild *chiloensis* had petioles with appressed and ascending pubescence; the petioles of the cultivated variety had spreading pubescence. Most of the resulting seedlings had petioles with appressed and ascending pubescence; some had spreading pubescence. One plant was found that bore some petioles of the one type and some of the other, a case of incomplete dominance. Daughter plants of this individual were grown and examined carefully. Some were like the wild *chiloensis*, some like the tame parent, and some like the mother plant in this respect. Here strains had arisen through bud variation that were not in the nature of degenerate forms, but that are to be explained as due to reversion. Theoretically at least, they might be the means of variety improvement.

DISCUSSION

Three distinct kinds of bud variation were met in the course of these experiments: (1) Fluctuating bud variation. Both of the apple trees and all of the strawberry plants that formed the starting points of the bud selection work of the Missouri Station, and most of the strawberry plants with which the Oregon Station began its work, were variants of this character. Without doubt a very large part of bud variation in general is of a fluctuating nature. (2) Running-out or degeneracy. In the work of the Oregon Station this running out took three forms: (a) a more or less complete loss of ability to produce fruit, through vegetative vigor remained unimpaired. (b) A partial loss of ability to produce runners. (c) A marked reduction in vegetative vigor, resulting in weak, degenerate plants. This degeneration may involve the entire stock of a variety that is being grown under a given set of conditions, or only a part of that stock. The work of the Oregon Station would indicate that a degenerate strain may occasionally return to the normal form from which it sprang—that is, it may “come back”. This is not unlike the

results obtained by Stewart of New York with the potato. (3) The third type of bud variation met is in the nature of a reversion to one of the ancestral forms.

In the light of these results it would seem that while bud selection may not be such an effective means of *improving the variety* as it was at one time believed, its importance in keeping the variety up to standard, in eliminating or weeding out inferior or degenerate forms, is not to be overlooked. *Crop improvement* is no less important than *variety improvement*. It is needless to say that the loss occasioned by this type of variety degeneration is apt to be found very variable. Without doubt there are bud-propagated crops or varieties, or there are seasons or sections when, where, or with which, it is a negligible factor. On the other hand investigators, propagators, and growers of bud-propagated plants should be on the watch for plants that show signs of deterioration. Neither should it be forgotten that occasionally bud variation may furnish the starting point for real variety improvement.

Bud Selection Investigation with Citrus Fruits

By A. D. SHAMEL, *Riverside, California*

THE study of bud variation in the trees of the leading commercial citrus varieties grown in Southern California was begun by the writer in April, 1909. While on a visit to Southern California for the purpose of studying methods of investigation having for their object the solution of losses due to packing, handling, and marketing of citrus fruits, the writer's attention was called to the variability of the fruits in the packing houses. The crops of navel oranges which were being packed for market at that time were found to contain many strikingly variable fruits, some of which were so distinctly inferior in appearance, texture, or other characteristics of the fruits of the typical Washington navel orange that they were being habitually thrown into cull bins. The differences in fruit characteristics of some of these fruits were so great that they could well be classed as definite sub-varieties of the Washington navel orange. The writer became interested in this condition and traced some of these strikingly variable fruits to individual trees or branches in trees in the orchards from which the crops came. This significant development of variable fruits borne by different trees in the Washington naval orange orchards and sometimes by branches on the same tree grown from a single bud, led to the systematic study of this condition in order to determine its relation to commercial navel orange production and marketing.

As soon as it was determined to make a systematic investigation of the bud variation problem in the Washington navel orange and other commercial citrus varieties in California, a preliminary survey was made of many orchards in all the leading citrus districts of

this section. The purpose of this survey was to determine the location of orchards and of plats of trees in the selected orchards where the phenomenon of bud variation could be studied under the most favorable conditions. Some six months or more were spent in this survey and as a result navel orange orchards were selected and in these orchards plats of 100 or more trees each were located where the environmental conditions were such as to warrant the belief that the results of these studies would be of the most value.

Some of the factors taken into consideration in selecting orchards and plats in these orchards were freedom from frost or other temperature injuries, absence of scale or other insect pests, and absence of fungous diseases. All of the orchards selected for the purpose of these studies had been planted upon virgin soil and little or no fertilizer of any kind had been applied from the time the orchards were planted until these investigations were begun. Particular attention was given to securing locations where the soil conditions were uniform and where the cultural and irrigation practices had been consistent during the entire history of the orchards. In all cases the history of the propagation of the trees in the orchards included the kind of stocks used and the sources of the buds from which the trees were propagated. In every instance not only in the first selection of plats of trees, but also in the subsequent selection of additional plats in the Washington navel orange or other citrus varieties, only those orchards were selected for study which were known to produce superior crops of fruit which were profitable to the growers and for which a reputation for the production of fine crops had been established in the leading markets.

In all of this work the hearty cooperation of the owners of the orchards selected for study was secured and has been maintained from the beginning until the present time. Additional labor for picking and assistance in assorting and handling the crops from the trees in the plats selected for study were furnished by the growers without any extra expense. Samples of fruit and almost unlimited supplies of bud wood have been given by the owners of the trees to the writer for use in making experimental and commercial propagation tests. In this way the investigation has been carried on with the minimum of public expense and has secured the active interest of all of the citrus growers in the localities where these studies have been made.

Fortunately the citrus industry in California is organized on a cooperative basis and about 75 per cent of the growers market their fruits through one major cooperative organization, the California Fruit Growers Exchange, whose principal place of business is in Los Angeles. This organization and others have fostered and encouraged these investigations from the beginning and have made possible the rapid utilization of the results of these studies in a commercial way which without such assistance could not have been introduced so fully and efficiently as has been the case.

While these studies were begun with the Washington navel orange for various reasons, the importance of this work soon became such that frequent requests were made to include other citrus varieties

in these investigations. Accordingly as opportunity presented, plats of trees in carefully selected orchards of the Valencia orange, the Marsh grapefruit, the Eureka, Lisbon, and Villa Franca lemons, and the Ruby Blood orange, have been added to the original plats of trees of the Washington navel orange.

The object of these studies has been to determine the characteristics and the frequency of the occurrence of bud variations in the trees of the citrus varieties under observation. The relation of these variations to the origin of strains in each of the citrus varieties and the comparative value of these strains for commercial fruit production have been studied. Introduction of improved methods for selecting parent trees as sources of bud wood and of securing reliable buds from these trees has been one of the important objects of these studies.

The plan of this work has been to keep individual tree performance records in plats of about 100 trees in each orchard selected for the purpose of these studies. These performance records included a record of the number and weight of the fruits of each commercial grade and size produced by each tree. The records also included a careful study of the variability of the fruits of each tree for a period of several years. Where the striking variations occur as limb sports the limbs have been carefully studied in their relation to the behavior of the remainder of the trees. Photographs and descriptive notes have been freely used in order to facilitate the work of securing definite information as to individual tree, branch, and fruit behavior.

Some of the records secured in these investigations together with conclusions as to the results of these studies have been published in United States Department of Agriculture bulletins as follows: No. 623, Citrus-fruit Improvement; A Study of Bud Variation in the Washington Navel Orange; No. 624, Citrus-fruit Improvement; A Study of Bud Variation in the Valencia Orange; No. 697, Citrus-fruit Improvement; A Study of Bud Variation in the Marsh Grapefruit. Additional reports on the results of these studies are now in course of publication by the Department of Agriculture and will likely be available for distribution at an early date. In this paper no attempt will be made to go into detail as to the results of these studies and anyone who is interested in the subject is referred to the above mentioned publications for further information.

In all of the citrus variations studied, bud variations have been found to be of frequent occurrence and of great commercial importance. In the established orchards where our studies have been carried on, these variations occur as individual trees and as individual branches or even individual fruits on the same tree. The variations studied thus far have been extreme and are easily recognized through differences in color, texture, size, shape, thickness of rind, quantity and quality of juice, number of seeds, and other clearly defined fruit characteristics. Some attention has been given to correlated foliage characteristics and to the marked habits of growth of trees of the different strains which have arisen from bud variations.

Many strains of each of the citrus varieties studied have been found in the performance record plats. These strains differ materi-

ally in the habit of growth of the trees, in foliage characteristics, in the season of production of fruits, and in the fruit characteristics themselves. Some of the strains produce fruits of very inferior commercial value, so much so in fact that the crops borne by the trees of these strains are of little or no value. On the other hand the trees of the best strains have been consistently found to produce the most regular and uniformly heavy crops of fruit. These productive trees of the best strains not only produce the most fruit, but have been found to produce the largest proportion of first grade fruit and that having the most desirable commercial size. This condition has been extremely fortunate from the standpoint of the commercial utilization of our results because a quantitative test of yields has frequently been a reliable indication as to the commercial quality of the fruits borne by different trees growing under similar environmental conditions. As a matter of fact, in more than 50,000 acres of citrus fruit in Southern California commercial tree performance records are being kept. These records include the total yield of fruit from each tree in the orchard with supplementary notes as to the tree conditions and the fruit characteristics. The purpose of these records is to definitely determine the good and bad trees in the orchards. From the most productive trees which usually are of the best strain, selections of parent trees as sources of bud wood for propagation, are made. Low yielding and undesirable trees are located through these records for the purpose of top-working them or replacing them with trees of the desirable strains. As a rule the extent of the occurrence of trees of the off-type strains increases with the number of bud generations from the original parent trees of the variety. In other words, in younger orchards which are further removed from the parent trees of the variety, a greater proportion of mixed strains arising from bud variations has been discovered in the orchards studied, than is the case with the older orchards which are more closely related to the original parent trees.

The explanation for this condition which is commonly believed is that under the previous method of bud selection where only non fruit-bearing wood or so-called sucker wood buds were secured for propagation, a larger proportion of the buds obtained in each instance was from the most vigorous growing and vegetative strains of trees, which, as a rule, are the least productive and commonly bear the most inferior crops of fruit. With the present day methods of securing bud wood where only fruit-bearing wood is secured for propagation selected from the most productive individual trees in the orchards, this tendency toward the introduction of vegetative strains is being largely, if not wholly, overcome.

On a Washington navel orange tree grown from a single bud we found as many as nine different strains of fruit. Sometimes these variations occur as individual fruits and in other cases as collections of many fruits borne by individual branches. While these different fruits all possess navels they differ in other characteristics to such an extent that they may be classed in some cases as distinct varieties of the navel orange. The navel or secondary orange itself has been

found to vary more or less, in some cases being very small or rudimentary while in other cases it develops to a very large size, sometimes as large as one-half of the primary orange itself. In some instances the navel is completely enclosed within the primary orange while in other instances it has developed as a protruding or attached secondary orange with similar characteristics to that of the primary orange. While the flowers of the typical Washington navel orange tree are usually abortive and imperfect, several instances have been found where the flowers are perfect and where the fruits set viable seeds. Under ordinary conditions the navel orange flowers do not develop pollen and owing to this primary cause and to the fact that frequently the ovaries are imperfectly developed, the fruits do not set seeds. However, a perfectly flowered strain of the Washington navel orange has been isolated where the fruits do habitually set their full complement of seeds each year.

An extensive list and description of bud wood variations in the navel orange and other citrus varieties could be given, but time does not permit at present of our going into such details. If further information is desired as to the nature of these variations it can be secured in the publications referred to in a preceding paragraph.

Experimental propagations have been made of all of the important bud variations studied in the course of these investigations. Enough evidence has been secured from these propagations to warrant the statement that all of the important variations have been isolated through bud selection. The results of these progeny studies are incomplete as yet, but as soon as it is thought that a full study has been made of their behavior, detailed reports will be issued giving the results of these studies in a similar way to that in which the characteristics of the original variations have been described. Most of the variations thus far propagated have been of interest, but are of little or no commercial value. Therefore, the propagations of these inferior strains have been done in experimental orchards on a limited scale. Only enough trees have been grown of each propagation to secure satisfactory evidence as to the transmission of the striking characteristics of the bud variations. The desirable variations, however, have been propagated and planted on an extensive commercial basis by citrus growers in Southern California so that at the present time there are several thousand acres of these trees available for study. In all of these cases the progeny of each parent tree has been kept separate in the commercial planting and the arrangement of the progenies in each orchard platted so that each progeny can be traced back to the parent tree. In this way an important reading can be secured of the comparative value for propagation purposes of the parent trees from which the progenies were propagated.

The commercial utilization of the results of these studies was made possible through the establishment in May, 1917, of a bud selection department by the California Fruit Growers' Exchange, a cooperative organization of about 10,000 citrus growers in California. This department is in charge of a scientific trained man and his purpose is to furnish to propagators reliable buds secured from super-

ior performance record trees of the commercial citrus varieties. Inasmuch as this is a cooperative, non-profit organization, these buds are furnished to propagators at cost. At the present time a charge of five cents is made for each bud, but owing to the large volume of business now being done it seems likely that this charge may be materially reduced in the near future. As a result of the demonstration of the improved production of trees grown from these carefully selected buds in many citrus orchards in all of the important citrus districts in California, all intelligent planters demand nursery trees grown from such buds. In fact, it is becoming apparent that nurserymen can not sell, excepting in isolated instances to newcomers and poorly informed persons, any other trees than those grown from what is commonly called selected buds. Nurserymen who have tried to continue their previous methods of careless bud selection and propagation have been forced out of business, while the nurserymen who have used the carefully selected buds have prospered. This condition is cited for the purpose of showing that most fruit growers are intelligent and demand, and are willing to pay for, reliable trees.

A somewhat comprehensive study of nursery practice in other lines than citrus conducted by the writer during the past ten years, has convinced him that a radical change in methods of propagation practised by many nurserymen is essential for the future welfare of the fruit industries. A great mass of evidence showing the deplorable results of careless work in the propagation of fruit trees has been accumulated which proves this statement beyond any question of doubt. A growing demand on the part of many deciduous growers in the eastern states for improved methods of propagation on the part of nurserymen has resulted in considerable activity recently among nurserymen looking toward the improvement of their methods of securing and propagating buds of the commercially important varieties of all fruits. If this work is carried on carefully and honestly and based upon adequate investigation of the conditions in each of the varieties concerned, it will doubtless result in as marked an improvement in orchard production as has been the case with the citrus in the opinion of the writer. On the other hand, there is a tendency among unscrupulous propagators to capitalize the work which has been carried on with the citrus, and to palm off on the public so called pedigreed trees which have as a matter of fact been propagated in the ordinary way. This movement will naturally be carefully watched in order to avoid if possible bringing discredit upon the legitimate effort to improve nursery practices, particularly those concerned in the selection of bud wood and in the selection of stocks. Previous similar abortive efforts of this character have occasioned a great deal of disappointment and it should be the attitude of every one concerned to watch out for, and to bring to the attention of the public, any illegitimate efforts on the part of unscrupulous propagators along these lines.

In conclusion the writer would like to say that in his opinion one of the most important results of these investigations has been the introduction of practical methods for keeping individual tree records

in orchards. These records are valuable not only in securing definite information as to individual tree and fruit characteristics, but also in measuring definitely the results of various orchard practices. For example, various theories of pruning of the citrus have been advocated strongly by various men in Southern California during recent years. These methods have been developed and advocated largely without any adequate information as to the effects of these different methods upon crop production. In the course of these investigations briefly described in this paper, individual tree records have been kept with plats of trees pruned by the leading advocates of different methods of citrus pruning in Southern California. In each case each method has been contrasted with unpruned trees. The results of these records have been extremely illuminating and have developed the fact that much of the pruning has been positively detrimental not only to the quantity, but also to the commercial quality, of the fruits borne by the pruned trees. These facts developed as a result of the individual tree records, and have come as a great shock to most of the citrus growers and to the pruners as well. It is not overstating the matter to say that these records have had a greater influence in checking the tendency towards radical pruning in citrus orchards in California than all other causes combined.

A similar statement can be made as to the utility of tree records in checking up different methods of fertilizing the soil, irrigating the orchards, and other cultural practices. Too much attention has been given in the past to the theories which have been strenuously advocated by men whose information concerning them has been incomplete. The facts are shown by the records of production and if the individual tree records are kept in a satisfactory manner this information can usually be relied upon. As a result of a wide experience in the salutary effect of tree record keeping in the control of the use of cultural treatments, the writer would like to make emphatic his opinion that the use of individual tree records will prove to be one of the most important, if not the most important, of any method of studying the results of these practices.

Concerning the Shedding of Flowers and Fruits and Other Abscission Phenomena in Apples and Pears

By ARTHUR J. HEINICKE, *Cornell University, Ithaca, New York*

THE June drop is an abscission phenomenon that is of special interest to the pomologists. It is well to remember, however, that the shedding of leaves, petals and other succulent organs, is very similar to the shedding of flowers and fruits that are still alive and fairly turgid. The detachment of unopened stone fruit buds and the removal of a portion of the cluster base, or even the entire flower bearing spur shortly after the blossoms fall, belong to the same category. The loss in all these cases of abscission is due to the

behavior of living cells near the base or at the node of the organ doomed to fall.

Observations and experiments concerning abscission in apples, pears and other fruits, have been carried on by the Department of Pomology at Cornell in connection with the study of factors influencing the set of fruit. Some of the results are presented in this paper.

THE SEPARATION ZONE

The pedicels of flowers or fruits often show a constriction at the base where they unite with the stem. Mechanical separation such as results from strong wind may occur at this constriction, but separation involving the activity of living cells often takes place just above, especially in younger organs. When flowers or fruits are allowed to abscise in a humid atmosphere, a band of glistening tissue appears around the base of the pedicel one to three days before detachment takes place. It may become a millimeter wide before abscission finally occurs. Sometimes it does not break through the epidermis, but it is nevertheless visible, appearing as a green line in contrast to the brown bark.

The band is nothing more than the rim of a plate of cells that lies between the pedicel and the cluster base. In longitudinal sections it appears as a water soaked line extending across the base of the flower or fruit stem, near, but not always at, the constricted portion. Often it runs along a straight path, but other times it dips down or up where it crosses the conducting tissue. Examinations of longitudinal sections through the pedicel and cluster base of normal flowers or fruits, show that there is no apparent difference between the cells of the region in which abscission occurs and those of adjoining tissues, although the cortical cells in the constricted portion are usually somewhat smaller than those in the broader portion of the pedicel.

During the early stages of abscission when the separation zone is but two or three cell lengths wide, it is usually difficult to obtain a sharp definition of the tissue involved. This is probably due to a gelatinization of the thick cell walls. In later stages the zone may include 10 to 12 tiers of elongated cells with thin walls and large nuclei. The ringed elements of the vascular tissue which passes through this cushion are sometimes stretched like a spring, but more often they break leaving fragments within the zone.

Hydrochloric acid applied to the sections of apple and pear tissue normally stains the lignified vascular elements and stone cells a cherry red. This is because such tissue contains phloroglucin which together with hydrochloric acid affects lignified tissue in this characteristic manner. Just prior to separation, the walls of two to six tiers of cells in the abscission region likewise give the red color when treated with hydrochloric acid which indicates that lignification has occurred. This test will often show the upper limits of the abscission zone even before the line becomes visible by its water soaked appearance.

Under laboratory conditions, the lignified layer was found in all cases excepting on the stems of several mature Bartlett pears that

were allowed to separate as a result of abscission and without mechanical interference. Examination of the abscission ends of flowers and fruits shed under orchard conditions, reveals the presence of the lignified layer in most, but not in all cases. The lignified layer is probably not an essential feature of abscission. No doubt it results from an accumulation of food materials that can no longer pass through the separation zone after the abscission process has been initiated. Lignification is frequently associated with a condition of senility.

- Sections treated with hydrochloric acid and Flückigers and other modifications of Fehlings test for reducing sugars gave a heavy, but non-localized brick red precipitate both before and during the abscission process. No precipitate was obtained before inversion, except in a single case where the test was conducted with material preserved in formaldehyde. The precipitate in this case was confined to the abscission zone. Starch was not found in any of the sections.

Eosin is often retained by the abscission tissue even after it is washed from adjoining cells. Other common stains usually leave the abscission zone lighter colored. The orange color occasionally obtained with safranin probably indicates the presence of pectin bodies. Other color and microchemical tests for such compounds, however, did not give very satisfactory results.

Nitrates were occasionally found in sections of the cluster base by the diphenylamine sulphuric acid reaction, but localization with reference to the separation region was not observed at any stage. The same is true of iron compounds which were detected by potassium ferro, and potassium ferricyanide. Catalase activity seemed to be especially marked in the separation zone as indicated by the lively effervescence following the application of a drop of hydrogen peroxide to the section.

The cells in the abscission zone are dissolved more readily than adjoining tissue by either a concentrated solution of sulphuric acid or potassium hydroxide. The lignified layer at the base of the pedicle dissolves slowly under such treatment as do the vascular tissues. When a fresh turgid section is placed on a slide without a cover glass, the cells in the abscission zone lose water more rapidly than those in adjoining tissues. As a result the tissue in this region is torn apart and separation of the pedicel from the cluster base occurs.

It should be remembered that the peculiar behavior of tissue at the base of organs that may be shed, is not apparent until after the abscission process has been initiated. In sections through cluster base and pedicels that will hold, the tissue in this region shows same chemical and physical properties as adjacent tissue.

Under humid conditions and when not disturbed, separation takes place just below the lignified layer and along the upper row of cells in the abscission zone. Abscission, however, may occur soon after the process has been initiated and in such cases some of the cells in the separation zone may adhere to the detached organ. Under field conditions, detachment, no doubt, frequently occurs at this stage as a result of mechanical assistance of wind or gravity.

The newly exposed scar formed under humid conditions is usually saucer shaped and suggests a partially healed pruning wound

with its roll of callus around the edge. The tissue corresponding to callus, however, is not entirely absent from the center of the scar. When seen under a hand lens, the surface of this tissue resembles that of the blackberry or osage orange, the cells being well rounded and irregularly arranged. Occasionally ragged edges of torn cells can be observed. The cells on the surface of the scar separate readily from one another. After a few moments exposure to dry air they collapse and assume a brown color. Several days later the scar becomes protected by a number of layers of suberized cells which appear to be continuous with layers of similar cells on the stem. Lignified tissue has not been observed in the protective layer of the apple and pear, but a distinct cork cambium often forms some distance below the surface of the original scar.

SOME CHARACTERISTICS OF FRUIT DOOMED TO FALL

Fruits that are doomed to fall can often be distinguished from those apparently set even before activity in the abscission region is discernible. This is especially true during cool, humid weather when abscission proceeds slowly. The fruits that hold gain more rapidly in size than those doomed to fall.

Under humid conditions and if the abscission process does not proceed too rapidly, the fruit destined to fall tends to assume characteristics of maturity while still attached. The normal surface color occasionally develops, and the flesh often has the characteristic color and aroma of ripe tissue. This is especially noticeable in case of fruits shed at more advanced stages. Pears and peaches which are forced to abscise several weeks before they would normally mature become soft and edible even before they are separated from the stem. When placed in 95 per cent alcohol the tissue becomes dark brown as compared with the lighter brown color developed by tissue that holds. This probably indicates chemical changes that accompany abscission and precede maturity.

When excised branches containing leaves and spurs with young fruits are exposed in relatively humid atmosphere so that transpiration is not too rapid, the fruits destined to fall will wilt in a few hours, while those apparently set remain turgid much longer, although they too will ultimately wilt. When all leaves are removed from the stem the large fruits often remain turgid at the expense of those that would soon drop. This behavior is no doubt due to difference in sap concentration, such as the following:

Lot, Variety and Date	Date 1919	Depression of Freezing Point	
		Fruit that Sets Degrees C.	Fruits doomed to Fall Degrees C.
1. Bartlett Pear	May 29	0.896	0.808
2. Bartlett Pear	June 3	1.027	0.793
3. Howell Pear	June 3	0.963	0.835
4. Howell Pear	June 3	1.016	0.833
5. Beitigheimer apple	August 6	0.957	0.700 (turgid)
6. Beitigheimer apple	August 6	0.950	1.155 (wilted)

The figures presented are the averages of duplicate determinations of at least two samples from each lot. In most cases ground and macerated tissue was used instead of sap for the freezing point determinations. Tissue previously killed by freezing gave the same results as fresh material. Case 6 illustrates that data obtained from wilted tissue may be misleading. Incipient wilting commonly occurs under orchard conditions, and material obtained at noon on a sunny day would therefore give different results than that obtained early in the morning.

The difference in osmotic pressure between normal fruits and those expected to fall is also shown by the fact that the latter will lose weight more rapidly than the former, when both are detached from the spur and exposed to a drying atmosphere. For example, immature Bartlett pears exposed for 12 hours in the laboratory lost 27 per cent of their weight while fruits destined to fall lost 40 per cent. Similar results were obtained with other varieties of the pear and apple.

The catalase activity of fruits that are doomed to be shed is less than that of fruits apparently set. This was shown by the following method: One gram of macerated tissue neutralized with calcium hydrate and mixed with 25 cubic centimeters of water, was placed in an oxidase apparatus where it was allowed to act on one cubic centimeter of neutralized hydrogen peroxide at 20° C. for five minutes. Under these conditions the tissue from normal fruits caused a pressure ranging from 0.4 cubic centimeter to 1.5 cubic centimeters of mercury, while that from doomed fruit was only one-third to one-half as great. When the volume of gas evolved was measured it gave the same relative results.

SOME CONDITIONS OR TREATMENTS THAT INDUCE OR HASTEN ABSCISSION

The conditions of the flower is an important factor in the June drop that is easily overlooked. Abscission of flowers or young fruits usually follows injury from cold which may manifest itself in abnormal stamens and pistils. The flower is influenced in a similar manner by nutritional conditions. For example, when apple stems containing dormant flower buds are placed in a one-tenth to one-thousandth molecular solution of sodium nitrate, the flowers may open in spite of injury to the leaves. The petals of such flowers, however, will be smaller, and pale or greenish as compared with those of checks on twigs standing in water. The stamens are often dwarfed or entirely misshapen and the pollen from apparently normal anthers on nitrated flowers germinate poorly, if at all. Similar observations have been made in connection with fertilizer experiments involving heavy applications of nitrogen. If nitrogen does not injure the flower it may help to hold the fruit as will be shown later.

When the twigs are placed in sugar solutions, the leaves may be dwarfed, but the petals of the flowers will be much larger and decidedly pinker than the checks. The stamens and pistils are usually large and well developed, and the pedicels are stiff and woody. Such

flowers will often set and begin to form fruits on excised twigs under greenhouse conditions.

The past season many pear and apple spurs produced flowers with stems only half or even a third as long as normal for the variety. The stamens and pistils of such flowers were apparently normal, but nevertheless all were shed. These short stemmed flowers were frequently associated with weak spurs, especially in the case of the pear. As previously shown, the flowers on such weak spurs will be abscised in most cases unless they are effectively fertilized, even though flowers on strong spurs are retained by relatively poor fertilization. As compared to weak spur, the previous seasons' growth of vigorous spurs is longer, the new spur growth or cluster base is heavier, the bud leaves are more numerous, there are more flowers to the spur and the weight of the lateral growth is greater, all of which indicates an abundance of reserve food in adjacent tissue.

Injury to the pistil of normal flowers is generally followed by abscission even though injury to other portions of the flower may or may not be associated with the drop. If the fleshy portion of the fruit is removed, separation of the remaining stub from the stem invariably occurs within a week or two. The younger the fruits at the time the treatment was given, and the shorter the stub, and the weaker the cluster base, the sooner separation occurred. The time between treatment and final separation varies also with the variety. Is self fruitfulness or self barrenness influenced by the ease with which the potential abscission tissue is stimulated into activity?

If placed in a humid atmosphere, the terminal portion of the cluster base from which all flowers and bud leaves have been removed will be detached. Abscission occurs just above the highest remaining leaf, flower or bud. If all leaves and flowers are removed from the cluster base, separation takes place just above the ring of bud scale scars. The healed-over wounds that remain in these cases are easily mistaken for fruit scars.

Flowers will soon separate from spurs that have been exposed for a few moments to an atmosphere of illuminating gas; but such treatments will not always force abscission of fruits. Entire flowers will fall sooner after being gassed than pedicel stubs from which the ovary has been removed before exposure. The stimulus seems to be more or less indirect.

When the entire fruit is coated with grafting wax, abscission generally follows. However, fruits that are nearly mature hold much longer after such treatment than younger specimens. Excised twigs with their ends standing in water and exposed to laboratory air will lose their fruits much sooner than similar twigs exposed in the orchard. This no doubt is due to the difference in temperature and also to the contamination of the laboratory air.

It is interesting to note that excised twigs will lose their fruits even in pure air, provided they are not allowed to wilt. Partially developed fruits on excised twigs and abundantly supplied with water will increase in size even more rapidly than fruits on attached twigs. Continued growth activity however is not possible in the former case and as a result fruits soon mature and fall.

Severe root pruning in early spring such as results from deep plowing of sod close to the trunk may be a factor in the abscission of immature fruit as it is in succulent organs of many other plants. A case has come to my attention when one side of a row of apple trees previously in sod was plowed in this manner just at the time the petals were falling. Most of the fruit from the plowed side of the trees dropped, while a good crop was held above the uncultivated area. Abscission commonly follows when the water supply is suddenly reduced. The removal of roots on one side of peach trees in August, however, was not followed by any tendency of the fruits to drop nor by a noticeable reduction of their size as compared with the checks.

SOME CONDITIONS OR TREATMENTS THAT DELAY OR PREVENT ABSCISSION

Abscission of the pedicel stubs usually occurs within a week or ten days after the fleshy portion of the fruit has been removed. But if water is pulled through the stub by means of a suction pump, separation is delayed. A drop of concentrated sugar solution placed on the cut surface of the pedicel has a similar effect. That the sugar solution actually draws water can be demonstrated by fixing a capillary tube to the pedicel stub. The column of liquid will rise in the tube containing sugar, while it falls in a similar tube containing water only. The suction developed by the pump or by the sugar solution seems to act as a substitute for either the "pulling power of transpiration" which apparently prevents abscission when an active leaf is held on detachable tissue, or for the osmotic force which is a factor in holding fruits with a high seed value.

Water may be forced into the ends of excised twigs and will exude from the cut surfaces of pedicel stubs for several days. This treatment also delays separation. Water flows more readily from the pedicel stubs attached to strong spurs than from those attached to weak spurs. Abscission is delayed longest where the flow of water is greatest. It is interesting to note that water may be forced through the flower stems even after the abscission zone becomes apparent.

Petioles are soon separated from the stem after the leaf blades have been removed. However, when water is forced into the base¹ ends of excised twigs abscission of all petioles is delayed. Under such conditions the stubs in the basal portion of the twig hold longer than those in the terminal part of the same year's growth, but under normal conditions leaf fall generally occurs latest on the newer wood. This is probably because the young leaves receive the best supply of water and mineral nutrients. Older leaves located on strong nodes such as are commonly found near the end of the "first" or early twig growth, may hold longer than younger leaves produced on weaker nodes of the "second" growth.

The following experiment shows that the presence of nitrogen in the tissue is an important factor in delaying leaf fall. The increase in the set of fruit which sometimes results from early applications of nitrogenous fertilizers may be due to the same fundamental causes.

During the first week in September, 1919, three to six pounds of sodium nitrate were applied in a semi-circle under one side of each of several young and old apple trees. The leaves on the branches above the corresponding side became dark green within a few weeks, and they remained on the tree until killed by a freeze in the latter part of November. Those on the untreated portion of the tree turned yellow during the latter part of October, and practically all had fallen before the middle of November.

Abscission of petiole stubs on excised apple twigs that were standing in a molecular solution of sodium nitrate for 12 to 24 hours occurred several days later than on those standing in water. The tissue in the bud shoulder may be injured by too much nitrogen and in such cases the dead petiole stubs adhere. A relatively strong solution of nitrate soon causes wilting of the leaf tissue. It is certainly true that abscission is inhibited, or at least delayed, if the tissue is not turgid. But the presence of nitrate in some way or other seems to counteract the influences that hasten abscission even in turgid tissue. In this connection it is interesting to note that leaves on ringed twigs become stiff and leathery and they drop four to six weeks sooner than normal. They evidently become mature as a result of the accumulation of assimilates which probably cannot be utilized or translocated without sufficient quantity of nitrogenous material.

When an excised spur with fruit is immersed in water abscission does not occur even though treatment has been given which is normally followed by separation. The lenticles on the immersed cluster base may produce white cellular masses indicating that the growth activity has not been entirely suspended. Enclosing cluster bases in a large sealed vessel containing either air or illuminating gas also prevents abscission. However, a coating of grafting wax over cluster base and fruit pedicel does not delay separation.

CONCLUDING REMARKS

The facts here presented and those recorded in the literature are not sufficient to afford an entirely satisfactory explanation of the behavior of the cells in the abscission zone. Undoubtedly, the causes that stimulate or excite the peculiar changes in this region are associated with variations in nutrition and water supply. If the tissue above the plane in which separation may occur is abundantly supplied with water and other substances that counteract maturity or favor translocation or utilization of assimilated material, conditions apparently are not favorable for manifestation of the meristematic nature of cells in the potential abscission zone. In many fruits effective fertilization helps to bring about these desirable conditions, but it should be remembered that development of seeds is only one of several possible means of causing a set. Self fruitfulness may be associated with the fact that the cells at the base of the pedicels of flowers on such varieties are not as easily stimulated into abscission activity as similar cells of self-barren trees.

Scion Root Production by Apple Trees in the Nursery

By J. G. MOORE, *University of Wisconsin, Madison, Wisconsin*

THE common practice in root grafting apples in Wisconsin is to use a long scion. The purpose of the long scion is to permit placing the point of union of the graft at some distance below the surface of the ground in planting. The object of deep planting is to induce the development of roots from the scion, producing what is commonly known as "own-rooted" or "scion-rooted" trees. Many northern orchardists hold that the roots produced by scions from hardy varieties are hardier than the majority of seedling roots upon which they are grafted, and such trees are, therefore, much sought after in sections where winter root killing is likely to occur.

This paper is a report on observations made of the behavior of grafts of various varieties commonly grown in Wisconsin as regards scion root production. Preliminary work was begun in 1914 and the work has been continued until 1919 when unfavorable conditions in the nursery stock made it inadvisable to incorporate data for that year with that previously taken.

The trees observed have been largely three year old nursery trees, grown under conditions commonly found in Wisconsin nurseries. The only exception is in the case of those dug in 1918. The grafts producing these trees were planted at varying depths in order to study the effects of depth planting upon scion root production.

Four factors may possibly influence scion root production by apples under ordinary conditions,—variety, soil moisture, depth of union below surface, and the character of the union made by the stock and scion. Data were not taken as regards the last factor, but observations tend to support the conclusion that when poor unions occur scion root production is encouraged. While age of the plant at digging is not a direct factor in influencing scion root production, it does have a marked bearing upon the amount of root production at the time of observation.

EFFECT OF VARIETY

There are wide differences in the ability of different varieties to produce scion roots. While there is some fluctuation from year to year in the relative percentage of trees of given varieties which produce roots, for the most part their relative ability holds fairly constant. Even when wide differences occur within the variety in different years, the relative rooting of various varieties is reasonably constant.

This tendency is clearly indicated in Table I. Trees showing any roots arising from the scion are classed as scion-rooted.

TABLE I
Scion Root Production

Variety	1914		1915		1916		1917		1918		Average Per cent Rooted	Total Trees Examined
	Trees	Rooted Per cent	Trees	Rooted Per cent	Trees	Rooted Per cent	Trees	Rooted Per cent	Trees	Rooted Per cent		
Wealthy ..	150	57.3	145	47.5	3458	5.4	3465	26.2	243	25.9	32.5	7,464
McMahon	100	76.0	440	58.1	799	28.0	1138	66.2	330	68.5	59.3	2,807
Whitney ..	50	42.0	360	41.4	1049	12.5	—	—	248	54.6	37.7	1,707
Wolf River	30	46.6	218	22.0	238	5.5	342	56.4	—	—	33.6	1,098
Patten...	50	16.0	573	12.1	860	4.6	410	6.8	—	—	7.4	1,893
N'western ..	150	60.7	747	44.1	1382	5.1	4151	43.2	303	50.5	40.7	6,583
Okabena	40	12.5	275	24.4	1041	11.0	663	44.5	—	—	23.1	1,979
Oldenburg	150	44.4	319	24.8	1106	11.2	1791	29.8	278	26.6	27.4	3,566
Pewaukee	75	34.6	121	86.1	536	5.6	1540	74.2	278	73.0	54.7	2,550
Hibernal	—	—	374	45.5	386	23.2	581	56.6	—	—	45.1	1,317
Livland ..	—	—	145	82.8	748	36.2	950	54.6	295	95.9	69.9	1,869
McIntosh	—	—	298	35.6	302	7.0	721	71.5	239	55.2	42.4	1,560
Hyslop ..	—	—	138	75.0	354	26.0	341	91.0	293	71.3	65.8	1,326
Percless	—	—	658	36.7	—	—	—	—	301	30.9	33.8	959
Transcend- ent ..	—	—	33	72.7	178	7.3	133	74.5	—	—	51.5	311
Delicious ..	—	—	459	1.5	475	8.8	1114	18.5	—	—	9.6	2,108
Windsor	—	—	—	—	—	—	584	6.4	—	—	6.4	624
Banana ..	—	—	71	1.4	—	—	—	—	—	—	1.4	71
Total												39,791

The fact that a scion produces some roots is not the only measure of its root producing ability. An attempt was made to roughly classify the scion-rooted trees into two groups on the basis of the probable ability of the scion roots to support the trees in case the stock roots were lost. Such trees were classed as "Strong scion rooted." This classification was necessarily based upon the judgment of the person making the counts and while not absolutely accurate does give fairly reliable data. These data are presented in Table II.

Two interesting facts are apparent in this table. With most varieties even after three years in the nursery, the number of trees having sufficient scion roots to support the tree is very small. While for the most part varieties showing a relatively large number of trees producing scion roots also have relatively large numbers showing "strong scion roots" there are some notable exceptions as North-western and Pewaukee.

SOIL MOISTURE FAVORS SCION ROOT FORMATION

Soil moisture is doubtless a very important factor in scion root development. Nursery stock grown under field conditions of soil and location which favor dry soil, produce fewer scion-rooted trees with weaker scion roots than when grown on moist soil. Table III gives the data collected in 1915, the only season in which the trees

TABLE II
Number and Per Cent Strong Scion-Rooted

Variety	1916		1917		1918		Average Per cent
	Number	Per cent	Number	Per cent	Number	Per cent	
Wealthy	20	.6	12	.3	1	.0	.3
McMahon	10	1.3	99	8.7	15	5.0	3.8
Whitney	6	.6	—	—	11	4.0	1.5
Wolf River	0	.0	7	2.0	—	—	1.0
Patten	0	.0	1	.2	—	—	.1
Northwestern	2	.1	53	1.3	1	.3	.6
Okabena	16	1.5	38	5.7	—	—	3.6
Oldenburg	9	.8	14	.8	0	.0	.5
Pewaukee	0	.0	111	7.2	0	.0	2.4
Hibernal	13	3.4	54	9.3	—	—	6.3
Livland	9	1.2	17	1.8	48	16.0	6.1
McIntosh	0	.0	66	9.2	0	.0	3.1
Hyslop	15	4.2	192	35.5	43	15.0	18.2
Transcendent	1	.7	19	14.3	—	—	7.5
Delicious	4	.9	26	2.3	—	—	1.6

dug were so located as to make possible a collection of data relative to differences in soil moisture.

TABLE III
Scion Roots Produced Under Different Soil Moisture Conditions

Variety	Trees Observed		Scion-Rooted		Strong Scion-Rooted	
	Moist	Dry	Moist	Dry	Moist	Dry
Peerless	263	311	42.6	31.4	6.1	5.8
Northwestern	142	328	63.4	24.1	18.3	2.7
McIntosh	94	110	56.4	29.1	21.3	1.8
Hyslop	40	98	100.0	50.0	100.0	23.5
McMahon	31	103	87.1	32.0	58.0	10.7

DEPTH FACTOR

Observations made in 1915 showed that although grafts were made with long scions for deep setting, in nursery practice there was wide variation in the actual depth at which the graft union was placed below the surface. These observations also indicated that scion root production was influenced by depth of planting. Arrangements were made with the nursery with which the work was being done to plant several thousand grafts of different varieties at varying depths. The scions were left approximately eight inches long. A representative of the college planted the grafts, measuring accurately the depth of planting. Because of soil conditions some of those to be set at six inches were not gotten to that depth, although the major portion were. The influence of depth of planting is shown in Table IV.

TABLE IV
Per cent Scion Rooted, Light Scion Rooted, Strong Scion Rooted

Depth of Planting	Per cent scion rooted						Per cent light rooted						Per cent strong rooted					
	2	3	4	5	6	Aver-	2	3	4	5	6	Aver-	2	3	4	5	6	Aver-
	inch	inch	inch	inch	inch	age	inch	inch	inch	inch	inch	age	inch	inch	inch	inch	inch	age
Wealthy	8	18	39	71	66	74	8	18	37	29	34	26	0	0	2	0	0	0
McMahon	31	56	76	87	84	68	31	56	74	80	73	64	0	0	3	7	12	5
Whitney	46	40	46	71	90	56	46	40	46	71	62	52	0	0	0	0	28	4
Northwestern	27	40	55	64	59	50	27	40	55	64	57	50	0	0	0	0	2	0
Oldenburg	9	13	25	37	40	27	9	13	25	37	40	27	0	0	0	0	0	0
Pewaukee	53	76	75	68	86	73	53	76	75	68	86	73	0	0	0	0	0	0
McIntosh	26	72	57	61	66	55	26	72	57	61	66	55	0	0	0	0	0	0
Livland	100	92	98	95	96	96	96	80	85	78	63	80	4	12	13	17	33	16
Hyslop	64	55	65	81	90	71	56	52	61	65	49	57	8	3	4	15	40	15
Peerless	5	22	33	37	47	31	5	22	33	37	47	31	0	0	0	0	0	0
Average	36.3	50.2	58.5	63.5	68.3	56.2	35.3	48.5	56.1	59.4	57.3	52.0	1.1	1.7	2.4	4.1	11.0	4.3

The data show the depth factor to be of considerable importance in scion root production. While there are some instances in which deeper planted grafts did not produce scion roots as well as the shallower set ones, for the most part the increase in root production is in proportion to the depth of planting.

The effect of depth of planting upon scion root production is doubtless an indirect one, the direct cause of better root production being the increased soil moisture surrounding the basal portion of the scion.

AGE

As previously stated most of the work has been done with trees having made three years growth in the nursery. Some two year old trees have been observed, but the percentage of trees of this age possessing any scion roots was very small and the roots were mostly fibrous and of small diameter. In no case have we observed a two year old nursery tree grown under ordinary nursery conditions possessing sufficient roots to sustain it were the stock roots removed. It is clearly evident that if a large proportion of apple trees purchased by fruit growers are to possess at the time of planting scion roots sufficient to support them, it will be necessary to devise some new methods of propagation.

Doubtless many of the long scion trees which show few or no roots at planting in the orchard, develop them within two or three years after planting. However, if it is not so, then the additional care and expense in propagating trees from long scion grafts as now practised is largely wasted.

Some Results as to the Response of Fruit Trees to Pruning

By W. H. CHANDLER, *Cornell University, Ithaca, N. Y.*

THE general purpose of the experiments with pruning being conducted at Cornell University is to test systems of training for some of the different fruits. Recognizing, however, that the response of the tree to the pruning necessary to secure a given form is very complicated and might not be the same under different environmental conditions, records are being kept other than merely those concerning yield and top growth. If the responses can thus be measured in terms of more fundamental activities that determine yield or top growth, it is hoped that the data secured may be more trustworthy for conditions similar to those under which the work is done, and more useful to workers in different environmental conditions. Necessarily, studies in training trees must for final results be continued through a large portion of the life of a tree and this can be considered only as a progress report dealing with young trees.

One response of the tree to dormant pruning, and usually to that done in early summer, is well known. Near the point where a portion was removed the new growth gives an appearance of greater vigor. The leaves are larger and generally of a greener color, and the twigs continue length growth later into the season. It seems to be the general opinion that this increased vigor is explained by the fact that a reduced number of growing points and a reduced cambial area make use of the reserve food supply of the tree. This explanation seems to be open to question. Thus Kraus and Kraybill (1918) say: "Any pruning practice would certainly decrease the amount of storage materials actually remaining as a part of the plant, and in a large measure also the future synthesis of such material so that the relation of the nutrients in the plant to those in the soil about it, have been profoundly disturbed. That is to say top pruning, whatever its nature, would decrease particularly the available carbohydrates and other stored substances in relation to the soil moisture and nutrients." Butler, Smith and Curry (1917) have published the results of analyses for starch, saccharose and other materials in the different parts of seven year old apple trees. I have dug up trees of that age, carefully collecting all of the roots and weighing and determining the dry matter percentage of the different parts. Then by using the percentages of starch and saccharose given by the above authors, I have estimated the actual amounts of starch and saccharose to be found in the different parts of the tree at the time the buds are swelling. The following table is for a seven year old Bismarck apple tree.

Approximate amounts of dry matter, starch and saccharose at time buds are swelling, in case of a seven year old Bismarck apple tree that has been growing four years in sod.

Part of Tree	Pounds dry wgt.	Pounds starch	Pounds saccharose
1 year twigs	3.15	0.98	.12
Older branches	21.00	6.72	.17
Trunk	15.13	5.14	.11
Large roots	14.15	5.43	.28
Small roots	6.49	2.37	.06

Of course it is probable that by the method of analysis for starch used here the percentages secured are far too large, but such a small percentage of the total tree weight is composed of twigs or small roots that even if in those tissues, the ones from which most growth is made, the percentage of starch were much the larger, the total amount might be relatively small.

In addition to having been in sod this tree had borne several heavy crops, so the weight of the one year old twigs is smaller in proportion to the remainder of the tree than would be true under other conditions. Yet if all of the one year old twigs were removed it would constitute a rather severe pruning, certainly enough to add appreciably to the vigor of growth of the new twigs to be formed.

Yet the reduction in total carbohydrates for the tree has been very small. It would seem probable that the carbohydrate supply for the opening buds and cambial area left would be slightly increased, for a very large percentage of the opening buds would be on these twigs if they were not removed. Further, the cambial area of these twigs would be very much greater in proportion to weight than that in the trunk. The same should be true to a greater extent in case of the small roots, since they are much smaller in diameter. It would seem probable then that the reserve supply in twigs and small roots would be more quickly exhausted and that these would tend to draw upon the reserve in the trunk and larger roots and branches. Price (1915) found with apple trees that the starch disappears first from the younger wood.

It does not seem probable, however, that this slight increase in reserve carbohydrate supply could account for the increase in vigor of twig growth, for this reserve seems rather quickly exhausted. Thus Price found that starch had nearly all disappeared from the live tissue above ground by eighteen days after the leaves began to open, and it had largely disappeared from the younger wood within a few days after the leaves were opening. The concentration of soluble carbon compounds seems also very greatly to decrease as growth begins. Since only about 15 per cent of the osmotic concentration of the bark sap seems to be due to the action of electrolytes, the freezing point of the sap seems a fair measure of the amount of soluble carbon compounds present at different seasons. The following table gives the freezing point depression of bark sap of Elberta peach and wild sweet cherry twigs. Records for the apple show similar results.

1916	Elberta Peach		Wild Sweet Cherry	
	Freezing point depression °C	Moisture percentage	Freezing point depression °C	Moisture percentage
March 25	3.010	—	2.255	—
April 17	2.096	—	—	—
May 3	1.880	—	1.485	—
May 10	1.378	—	1.295	—
June 1	1.540	59.2	1.120	60.1
June 19	1.810	—	0.985	—
July 6	2.158	—	1.553	—
August 17	2.230	62.0	1.730	61.4
October 5	2.233	—	1.763	—
December 29	2.567	54.6	2.563	54.3

This tissue was not killed before freezing, but a number of trials indicate that while the concentration of the leaf is greatly increased by killing before the sap is expressed, no increase results in case of the bark of apple, peach, and sweet cherry twigs. In case of the peaches the leaf buds were open enough for the outer leaves to show

the midrib by May 5, and full bloom was May 18-22. The sweet cherry was the same as to leaves, and full bloom was May 12-14. It will be seen that the high concentration due to the reserve supply is rather quickly exhausted when growth starts. This decrease in concentration seems just as rapid in case of the pruned trees. If the reserve supply were responsible for the increase in vigor due to pruning, then pruning after this reserve is exhausted should not give the increased vigor. Yet there seems to be no measurable difference in response between pruning at blooming and earlier; and pruning as late as June 1 at Ithaca, on the year the above records were taken, gave results similar to those following dormant pruning.

Pruning by reducing the number of growing points reduces the leaf surface of the tree, as will be shown from experimental evidence later. This by reducing transpiration should reduce the demand for water from the roots. By reducing the number of growing points and the amount of cambial area, it should reduce the demand for mineral nutrients. Since during the season of rapid growth the carbohydrates supply continues low, being used for top growth, it would seem probable that early spring and summer root growth would be made largely from the reserve supply, and might be influenced rather slowly by the reduced carbohydrate supply in the top of the pruned trees due to the smaller leaf surface. The root system then should be nearly as large during the season of rapid top growth as if the tree had not been pruned. There would, therefore, be the same water and mineral nutrient supply for a smaller tree. It would seem probable then that the increased vigor of top growth would continue until the reduced size of the tree would be balanced by a reduction in root growth due to the reduction in leaf surface. Further evidence that this may be true will be given a little later.

If the above theory were true, then we should expect that in spite of the temporarily increased vigor of twig growth in the reduced number of twigs, pruning must be a dwarfing process. That is, not only is the tree reduced in size to the extent that the wood is removed, but if the leaf surface is reduced the amount of new growth must in the end be reduced. It would of course be expected that the extent of the dwarfing might be influenced by the nature and length of growing seasons and by the growth habit of the variety. Thus in a section where the growing season is so long that the first leaves formed may have ceased to function long before the end of growing weather, and where leaves formed late might still have a long season in which to function, it seems possible that pruning might have less of a dwarfing effect.

That pruning does have the dwarfing effect, Pickering has given rather conclusive evidence for the climate of England. For the climates of different sections of America so many workers have given evidence more or less conclusive that it does not seem best to review it in this brief paper. While Pickering's work seems strongly to indicate a reduction in growth as a result of pruning, his most striking result seems very misleading. In this he used, instead of whole trees, individual shoots on the same tree. This of course would

tend to reduce the error due to the great variation among trees, but it introduces a constant error in favor of the unpruned shoots. The pruned tree tends to reduce the dwarfing effect of pruning by increased vigor of growth during a portion of the first season after the pruning. If we are correct in assuming that the increased vigor of growth results at least partly from the fact that the water supply furnished by the undiminished (or but slightly diminished) root system goes to a smaller leaf surface, then if only a shoot on a tree were pruned the increase in vigor of new shoots from it would be less than if the leaf surface on the remainder of the tree were reduced by pruning. To test this, shoots on three year old nursery trees were selected, one on each tree. On half of the trees this shoot only was pruned back to one-half its original length, while on the other half shoots of the same length were pruned back one-half, but the remainder of the shoots on the same tree were pruned to about the same extent. At the end of the growing season the new growth was measured on the originally selected shoot from each tree. The following table gives the results:

Nursery Slayman Winesap, 1919

Treatment	Number of trees	Average twig length inches, before pruning May 23, 1919	Average twig length inches, after pruning May 23, 1919	Inches of new growth from each pruned twig Sept. 20, 1919
Tree pruned	30	29.2	9.9	32.0
Tree unpruned	30	29.2	9.9	9.9

These trees were closely planted and the season was dry, so the moisture supply was probably more largely the determining factor than it would be under average conditions. A record of the growth on the unpruned branches of the trees where only the experimental branch was pruned, was not kept. However, in some other trees in the same row some of the branches were pruned back to one-half their length, while other branches on the same tree were left unpruned. The following table gives the results.

	Number of branches	Number of new shoots to branch	Average shoot length inches	New growth from one branch inches
Unpruned	19	7.5	8.9	62
Pruned	21	5.5	7.2	39

Without question these results would have been different if the pruned branches had been on different trees, the entire tops of which were pruned in the same way. It seems that the pruned branches have actually been at a disadvantage in the competition for water, which must have been the limiting factor as to growth under the conditions of this experiment. Of course, if the water supply had been abundant, it is probable that different results

would have been secured; but the fact that a change in environment may so markedly change the relative response of pruned and unpruned branches, makes it clear that different branches on the same tree cannot be used in pruning experiments. These data tend to explain the ease with which one branch on a tree is suppressed as compared with the others, by pruning.

In the pruning experiments at Cornell University, which include about 1500 trees, the dwarfing effect of pruning has been measured not alone by yield and trunk girth, and in some cases twig growth, but also by leaf surface, and in some cases by the top and root weight of trees that have been dug. This brief report will be confined largely to results with these last. In all cases where leaf surface is given, the leaves were actually counted on the trees, and the average leaf area determined by measurement with a planimeter. The leaf samples were taken by beginning at the base of the branches and removing sample leaves at intervals outward to the end. In case of small trees but two sets of samples were taken from each tree, and the average areas secured from each sample compared. In the case of large trees as many as four sets of samples to the tree were secured. With apple and pear trees it was found impossible to collect mixed samples of spur and twig leaves and secure accurate results. Spur and twig leaves were therefore kept separate, and thus with large trees there would be eight sets of samples, four of spur and four of twig leaves. By this method not only was much greater accuracy secured, but by knowing the spur leaf area one would have a close approximation to the leaf surface at the beginning of the growing season. By this method also a longer period was available in which to do the leaf counting, since spur leaf counting may begin very soon after growth has started, while twig leaf counting cannot begin until after length growth has ceased.

In some nursery trees one year from the graft, selected as carefully as possible for uniformity in size, the opening buds were rubbed off the trunk to a height of about eighteen inches, while check trees receiving no pruning were measured and the leaves counted at the same time. At the end of the season the trees were carefully dug, all of the small roots being searched out of the soil and preserved. The roots were separated from the tops at the graft unions. The following table gives the results.

Nursery Delicious, 1917

Treatment	Number of trees	Average number of leaves before pruning June, 1917	Average number of leaves after pruning June, 1917	Average number of leaves Oct. 19, 1917	Weight of tops, grams, Oct. 19, 1917	Weight of roots, grams, Oct. 19, 1917
Pruned ...	16	173.2	44.0	149	168.2	24.0
Unpruned	14	145.3	—	272	236.6	33.2

It will be seen that although, as measured by the number of leaves, the pruned trees were the larger at the beginning of the experiment, the weight of the tops of the pruned trees is but 67 per cent of that

of the unpruned trees, and the weight of the roots but 72 per cent, after a season of growth. On the following year other trees in the same nursery planting, 113 in number, were carefully graded as to size; some were unpruned, while some had the lower branches removed to a height of about twenty inches, and others, in addition to this pruning, had some of the higher branches shortened back. Generally for each unpruned tree another tree of the same size was pruned by each of these methods; but sometimes when three trees of the same size could not be secured, one was unpruned, and the nearest tree to that size was pruned by one or the other of these methods. The following table gives the leaf surface after length growth had ceased, and the weight of the roots and tops at the end of the growing season.

Nursery Delicious, 1918.

Treatment	Number of trees	Average leaf surface before pruning, square inches May 23, 1918	Average leaf surface after pruning, square inches May 23, 1918	Average leaf surface Sept. 17, 1918	Average root weight May 19, 1919, grams.	Average top weight May 19, 1919, grams. (+ prunings)
Unpruned	41	756.48	756.48	1737.94	208.5	684.0
Little pruning . . .	33	819.14	470.27	1219.80	166.9	558.3
Much pruning . . .	39	775.70	291.61	895.96	125.3	494.3

It should be borne in mind that these trees were two years from the graft when the pruning was done, and the reduced size of roots and tops is caused by a reduction in growth during one season only. Thus we may assume that at the beginning of the experiment the root and top weight was approximately that of the unpruned trees in the previous table. Deducting that weight from the weights of pruned and unpruned trees in this table, we have, as the top growth made during the summer in which the experiment was conducted, for unpruned trees 447 grams, and for the more severely pruned trees 257 grams. Thus the growth made during that summer by the more severely pruned trees was but 57.5 per cent of that made by the unpruned trees. By the same method of calculation the growth made by the roots of the more severely pruned trees was but 52.5 per cent of that made by the unpruned trees.

It is well known that as peach trees become older the twig growth comes to be very small unless the trees are pruned somewhat severely. This of course is true in a measure of other fruit trees, but peach trees reach that condition much younger than others. It was thought possible that there might develop in the peach tree resistances to water movement that would cause this decline in growth, and that this condition might be such an important limiting factor as to be greater than the effect of a reduced leaf surface through pruning. While it is well known that under reasonably favorable moisture conditions a peach tree rather severely pruned will be smaller than an unpruned tree, it was thought possible that the total growth, as shown when the weight of the prunings is added to the weight of the

tree, might be as large or larger. In the spring of 1916, ten four year old Elberta peach trees were carefully paired as to size at that time, and one of each pair was pruned rather severely, the cutting being back into two year old wood. On the following spring all one year old wood was removed again from the pruned tree. It was thought possible that even though the leaf surface might be nearly as great on the pruned tree at the end of the season as on the unpruned tree, the total leaf surface available throughout the summer might be greatly reduced on account of the very small leaf surface on the pruned trees during early summer. The leaf surface was therefore determined both in June and in September. The following table includes a report on this experiment, and one on four Crawford Early peach trees, two of which were pruned in the summer of 1916 and spring of 1917; and four other Crawford Early trees, all of which were unpruned in 1916, but two of which had the one year old wood removed in the spring of 1917.

Effect of Pruning on the Leaf Surface and the Top and Root Growth of Peach Trees 4 Years Old at the Beginning of the Experiment

Treatment	Average leaf surface 1916 square inches		Average leaf surface 1917 square inches		Tree weight pounds	Tree weight + all prunings pounds	Root weight pounds
	June	Sept.	June	Sept.			
Elberta							
Pruned 1916 & 1917 . . .	14239	80659	31209	59579	96.3	116.4	27.4
Unpruned	24771	97850	98169	116344	116.3	116.3	37.3
Crawford Early							
Pruned summer 1916 spring 1917	2202	50034	18904	68070	75.8	97.4	20.9
Unpruned	17886	85721	74389	142920	111.9	111.9	34.6
Pruned spring 1917 . .			40681	79563	126.3	134.7	34.9
Unpruned			114516	144911	131.7	131.7	44.9

It will be seen that in all cases the leaf surface has been rather markedly reduced. On the other hand, except in case of the summer pruned trees, when the weight of the prunings has been added to that of the tree, the total top weight of pruned and unpruned trees is practically the same. The root growth, however, has been greatly reduced. When it is considered that this reduction in growth has occurred during the last two years of the six years during which the trees have been in the orchard, it will be realized how striking the reduction is. Thus if at the beginning of 1916 the roots weighed 15 pounds, then the root growth on the unpruned trees since that time has been nearly twice that on the pruned tree. Unfortunately we have no records as to the root weight of trees four years old, but it must have been ten pounds or more, since by records that we have the tops would then have weighed from 30 to 35 pounds. If the root weight at the beginning was ten pounds, then the root growth in the pruned trees since that time has been but 65 per cent of that made by the unpruned trees.

Thus it seems that with a greatly reduced leaf surface the pruned trees of this age have made as large a top growth as the unpruned trees, while the root growth has been greatly reduced. (It should be said that fruit was not borne on any of these trees during the experiment.) It seems probable that pruning, by reducing the leaf surface and the number of growing points, has thereby increased the water supply or the mineral nutrient supply, or both, to the growing points left, and thus, in line with the views of Kraus and Kraybill, has made possible a more complete use of the carbohydrates in top growth. Since for North American soils there is no recorded response in growth by fruit trees to applications of other elements than nitrogen, it seems possible that this increased top growth of pruned trees may have resulted from an increased nitrogen supply to the growing points. Fortunately, we have evidence as to the relative response in root and top growth to applications of nitrogen. In the spring of 1918, 65 peach trees were planted in the same orchard in which the above trees were grown. This is a sandy soil so low in nitrogen that only very poor corn crops could be grown unless nitrogen were applied. On 35 trees divided into three plots, one-half pound of nitrate of soda to the tree was applied in the spring of 1918, and three-fourths of a pound in the spring of 1919. No nitrogen was applied to the other 30 trees which were in two plots. It should be said that the trees were weighed when they were planted. At the end of the season of 1919 they were carefully dug, and root and top weight secured. Those unfertilized trees adjacent to fertilized trees were influenced somewhat in their growth by the nitrogen applied to the fertilized trees. In the following table the left hand column gives data for all fertilized trees, the middle column for all unfertilized trees, and the right hand column for all trees in the unfertilized plots that were not near enough to any fertilized tree to be influenced by the nitrate applied.

Effect of Nitrogen on Relative Growth of Root and Top of Peach Trees

	Fertilized with sodium nitrate 35 trees	Unfertilized 30 trees	Uninfluenced by fertilizer 15 trees
Average leaf surface 1916, square inches	9519	7351	6553
Average leaf surface 1917, square inches	24253	13075	10140
Average leaf surface for both combined, square inches	33772	20425	16693
Average weight of top after deducting weight at planting, lbs	8.71	5.24	4.28
Average dry weight at top growth, lbs.	4.96	2.99	2.44
Average weight of roots after deducting wgt. at planting, lbs.	2.92	2.23	1.99
Average dry weight of root growth, lbs.	1.55	1.18	1.05
Pounds of dry matter produced by 100,000 square inches of leaf surface, as top	14.68	14.64	14.62
Pounds of dry matter produced by 100,000 square inches of leaf surface, as leaves	10.78	11.04	11.08
Pounds of dry matter produced by 100,000 square inches of leaf surface, as roots	4.59	5.77	6.29

It is evident that while the nitrate has increased both top and root growth, it has not increased root growth to as large an extent as it has increased top growth. Thus, while the top growth of the fertilized trees is twice as great as that of the unfertilized trees, the root growth is only 50 per cent greater, or in other words, while a given leaf area has produced the same amount of dry matter as top growth in each of the 3 classes, the same area has produced 40 per cent more dry matter as roots on unfertilized trees than on those receiving nitrogen.

It seems probable then that when the nitrogen supply is abundant in the top, carbohydrates from the leaves are used for top growth in larger proportion than when the nitrogen supply is more limited. I know of no conclusive evidence that abundant water supply may have this result, but it seems probable that any condition which encourages vigorous top growth might have it, and there is circumstantial evidence that increased water supply may have this effect. Thus, during the summer of 1917 the rainfall at Ithaca was very great throughout the summer, and there was so much cloudiness that evaporation must have been very low. Trees in well drained soil made exceptional top growth. In the following spring, however, such trees, even when no winter injury could be found in root or top, made very short growth. The following table gives the leaf surface on such trees.

Effect of Pruning to Secure Modified Open Head on the Leaf Surface of Young Apple Trees. All Measurements in Square Inches

	Pruning	1916 Average surface	1917 Average leaf surface			1918 Average leaf surface		
			Spur	Twig	Total	Spur	Twig	Total
Northern Spy	Little Open Head	2400	1330	8001	9331	1891	7179	9070
		1890	761	7145	7906	1302	6825	8127
Twenty Ounce	Little Open Head	1893	464	10278	10742	1610	7184	8794
		1563	292	8133	8425	1389	6432	7821
Jonathan	Little Open Head	1716	2207	11392	13599	4975	6411	11386
		1682	1357	8109	9466	3511	5776	9287
Banana	Little Open Head	2262	2523	8744	11267	6346	5051	11397
		1512	1127	5751	6878	2504	5325	7829
Delicious	Little Open Head	1750	2640	11078	13718	6482	6193	12675
		958	1158	6021	7179	3271	5831	9102

It will be seen that with every variety but one the leaf surface is actually smaller in 1918 than in 1917, although that of 1917 is 4 to 8 times that for 1916. The explanation of this would seem to be that because of the favorable conditions for growth the carbohydrates were used so completely for top growth that they did not move to the roots in sufficient quantity for large growth.

The root surface at the beginning of 1918 being very small in proportion to the initial leaf surface, growth soon ceased on account

of the insufficient water supply. It would be expected that when twig growth ceased there would be an abundant supply of carbohydrates and that root growth would be accelerated and that later there might be a second twig growth. Such a second growth occurred on nearly all trees and especially on those that made the smallest initial twig growth, the Jonathan and Banana. These probably made the smallest initial twig growth because they had the largest spur system and, therefore, the largest initial leaf surface. The leaf surface given above, of course, includes that on the second growth.

To me these data strengthen the views expressed in 1914 that the increased vigor following pruning results not from increased carbohydrate supply, but from increased water supply, and as Kraus and Kraybill have suggested from increased nitrogen supply. This increase may result from the fact that during the early portion of the season the root system would be but slightly reduced while the transpiring surface and the number of growing points may be greatly reduced. On account of the reduced leaf surface to supply carbohydrate, however, root growth is eventually greatly reduced, so unless the pruning is very severe or is repeated, the increased vigor may not be evident by the following season. At any rate, unless the pruning is repeated there will come a time when the reduced transpiration, due to pruning, will be balanced by reduced root growth, resulting from the same reduction in leaf surface.

The last table was prepared to show the effect of the pruning necessary to secure an open head on the leaf surface of the trees. As would be expected, the leaf surface comes to be reduced as compared with trees permitted to follow their natural habits of growth. It will be seen that the reduction in leaf surface comes largely in the spur leaves. This, of course, would be expected. The following illustration gives an idea of the form to which these trees are pruned.

Effect of Pruning to Secure a Modified Leader, on Leaf Surface and Yield of Young Apple Trees

	Little prun- ing	Open head	Dif- ference
Average leaf surface 1916, square inches	41499	39532	1967
Average spur surface, 1917, square inches	33944	27692	6252
Average twig surface 1917, square inches	27710	28436	- 726
Average spur + twig surface 1917, square inches	61654	56128	5526
Average spur surface 1918, square inches	43180	33891	9289
Average twig surface 1918, square inches	20528	23839	-3311
Average spur + twig surface 1918, square inches	63708	57730	5978
Average yield 1915, pounds	3.3	2.1	1.2
Average yield 1916, pounds	54.1	23.6	30.5
Average yield 1917, pounds	41.7	36.7	5.0
Average yield 1918, pounds	96.4	64.0	32.4
Average yield 1919, pounds	114.1	60.3	53.8

There are generally five branches, the upper of which is the largest, the purpose of this being to give strong unions and avoid forks. To secure this form it may, therefore, be necessary to cut

back some or all the other branches. In addition the secondary branches of each main branch are so pruned that there will not be much interweaving of the branches. Nothing is cut off, however, unless the necessity is evident, so as a matter of fact less pruning is done than is commonly done by growers to secure no particular form. The pruning necessary, however, has reduced the leaf surface and, therefore, probably the growth. It has reduced the yield of young trees even more largely, however, as the following table giving records from 24 trees, 9 years old, composed of Baldwins, Rhode Island Greening, McIntosh, Wealthy, Oldenburg, Tompkins King and Northern Spy, will show.

While the fruiting has been rather markedly reduced the leaf surface has been reduced but slightly. This would be expected with apples and pears, since most of the fruit is borne from spurs, and even if the increased vigor of twig growth, due to pruning, were sufficient to bring the leaf surface to normal by the end of the season, the number of spurs would be reduced. The difference in leaf surface is, of course, reduced by the heavier fruiting of the unpruned trees. Pickering has shown that fruiting dwarfs markedly.

In our training experiments, we use various forms of the open head and various methods of securing the same and the typical central leader tree. As we have done the work, it has taken less pruning to secure this form than the open head form described above. Thus, taking adjacent trees in one-half of the 9 year old orchard including the same varieties as those in the above table, the average amount of wood pruned from a tree during the five years from 1914 to 1918 and the yield were as follows:

	Little prun- ing	Central Leader	Open Head
New wood, pounds	1.14	3.42	5.98
Old wood, pounds	1.77	2.49	4.22
Yield, pounds	264.21	220.97	200.10

From the other half of the orchard which contained McIntosh, Wagener, Oldenburg, Twenty Ounce, and Wealthy, the average amount of wood pruned from a tree during four years from 1915 to 1918 and the yield were as follows:

	Little Pruning	Central Leader	Open Head
New wood, pounds	0.29	1.73	2.23
Old wood pounds	1.07	1.44	2.43
Yield, pounds	333.81	307.62	254.19

The new wood is 1 year old and the old wood is 2 years old and thickly set with spurs. Of course, it is the removal of this new wood that will reduce the leaf surface of the tree. It is that wood, too, from which fruiting spurs will come.

More pruning has been given the trees trained to an open head than trees trained to the central leader. It should be said, however,

that while all of the trees pruned for the open head are growing satisfactorily into the form described above, not nearly all of the trees pruned for the central leader are developing satisfactorily into that form. In fact not only has the pruning been insufficient to force the trees into that form, but we now find that the branches have been left too thick, and in 1919 in that half of the orchard containing Baldwin and Rhode Island Greening more new wood was cut from these than from the open head trees. It seems probable that such varieties as Wagener, Wealthy, Rome Beauty and Northern Spy may be trained to the central leader form with a little less pruning and, therefore, less dwarfing than is required to secure the open head form described above. On the other hand, spreading varieties like Baldwin, Rhode Island Greening, Jonathan, and McIntosh, will have to be pruned the more severely to secure the central leader. Permitting the tree to follow its natural habit of growth with only crossing branches removed, certainly results in the largest yield while the trees are young. However, all of the split and broken trees in our orchard have had that kind of pruning.

It would be expected that in case of species bearing fruit from lateral buds or one year twigs, pruning to shape the tree would reduce the fruiting of young trees less than in case of spur bearing trees. We have been unable to study this problem in case of peaches and have as yet but meagre data from our cherry trees, but plum trees pruned to the same form of open head described for the apple and receiving as severe pruning, have more nearly equalled the unpruned trees in their fruiting. Thus, the open head plum trees have yielded 92 per cent as much as the unpruned trees in case of Reine Claude, 79 per cent as much in case of Burbank, 74 per cent as much in case of Shropshire and 99 per cent as much in case of German Prune. With these fruits as yet, pruning does not seem to have affected the yield through any marked stimulating effect on fruit bud formation or twig growth. The reduction in fruit borne seems to have resulted almost entirely from the reduction in size of the trees. Nearly all trees have fruited heavily enough to require thinning.

We have given but slight attention to the problem as to the best season for pruning. Pickering seems to find summer pruning to dwarf slightly more than dormant pruning. The evidence in America largely concerns the effect on fruiting only, and is very conflicting as to that. It is not easy to say when summer and dormant pruning have been equally severe. Thus, if dormant pruning is compared with pruning during the summer following and equal amounts of wood are removed, then the summer pruning removes a smaller percentage of the top, since that has increased in size. It would be expected that with equally severe pruning that which is done in summer would dwarf most since a large amount of foliage is removed before it contributes much to the growth of the tree. To test this, Northern Spy trees 3 years from the graft were left unpruned, pruned as growth was starting, and pruned on July 9.

The length and position of each 1918 twig was recorded before any pruning was done. Then 3 trees with as near to the same twig length as it was possible to secure them, were chosen. One

was marked for no pruning. On each of the other two enough of the 1918 twigs to constitute one-half of the total length were marked to be removed. These twigs were chosen by beginning at the top twig of the top branch and taking every other one until enough were marked to constitute one-half of the 1918 twig length. One of the trees was pruned at once and the other one July 9. Thus, the summer pruning removed one-half of the 1918 twig length plus the 1919 growth. It should thus have removed one-half of the active top as the spring pruning had.

The following table gives the results:

Nursery Northern Spy, 1919

Pruning	Number of trees	Average twig length May 20, 1919, inches	Average leaf surface July 9, 1919, sq. in.	Average leaf surface Sept. 20, 1919, sq. in.	Average top weight Nov. 5, 1919 (+prunings) lbs.	Average root weight Nov. 5, 1919, lbs.
Unpruned	20	271.0	2165.6	2007.1	1.86	0.80
Pruned May 20	20	274.3	2081.9	1897.9	1.81	0.83
Pruned July 9	20	272.4	*2195.4 **1142.9	1265.2	1.78	0.68

*Before pruning.

**After pruning.

The summer pruning seems to have had a very marked dwarfing effect while the spring pruning under the condition of this experiment, where the water supply was so limited as to cause some early leaf fall, seems not to have reduced growth. It should be borne in mind that the reduced size of the roots of the summer pruned trees represents the effect of the pruning during only the last of 4 seasons of growth. It is realized that what is presented here is not different from what might have been expected. The pomologist working with as cumbersome a medium as trees can scarcely hope to make important contributions to our knowledge concerning the fundamental nature of plant responses. On the other hand, physiological knowledge is so incomplete, and plant responses so complicated, that it certainly is not practical to predict the response of the tree to a treatment solely from evidence secured with other plants. It is with this justification that these data are presented.

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Comparison of Fall, Winter and Spring Pruning of Apple Trees in Minnesota*

By W. G. BRIERLEY, *University of Minnesota, St. Paul, Minnesota*

THE effects of fall, winter and spring pruning have been the object of study at the Minnesota Experiment Station since the fall of 1913. As in many other pruning projects, the orchard available at the time the work was started was not well suited to the study, but it was considered usable for preliminary studies. The orchard, although in sandy loam and cultivated regularly, was irregularly spaced and the trees were crowded with plum seedlings. Most of the trees were seedlings of Hibernial or Patten Greening, but some were seedlings from the Dartt collection. The orchard was planted by Prof. S. B. Green who intended to do fruit breeding work in it. Evidently regularity in planting was not considered necessary, as the number of trees in the rows varies from five to ten, the average being about six.

When this pruning study was started in the fall of 1913, the trees were from eight to ten years of age and had not been pruned for at least five years. The first pruning in 1913-14 consisted largely of renovation. In 1914-15 and subsequent seasons the pruning generally was the necessary follow-up of the renovation work. Observations were made on the response of these trees to renovation, but will not be mentioned further at this time.

During the first two seasons of the experiment the work was arranged so that a block of three rows was pruned in midwinter, and another of five rows was pruned in early spring. In order to get a somewhat greater range of season, particularly to include late fall pruning, the work of 1915-16 and 1916-17, was arranged so that the block previously pruned in midwinter was pruned a row per month during November, December and January. The block of five rows, previously pruned in the spring, was divided up so that a row was pruned in each month from February to June. In all cases the pruning work was done as nearly on the fifteenth of the month as weather permitted. Bad weather in 1914-15 set all the work back one month. Table I shows the time of pruning of each row during the four seasons.

As might be expected, some of the winter pruning was done in near-zero weather, and in almost every winter month of the four seasons the apple wood was frozen when pruned. In two or three cases the trees were coated with ice. This statement is not intended as an effort to put winter pruning in the North in the category of outdoor sports, but to show that the winter pruning was done under conditions which were not generally supposed to be the most favorable to the tree. The pruning at other times can be considered as done under normal conditions.

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TABLE I
Month of Pruning for Row and Season

Row	1913-14	1914-15	1915-16	1916-17
1	December	January	November	November
2	December	January	December	December
3	December	January	January	January
4	March	April	February	February
5	March	April	March	March
6	March	April	April	April
7	March	April	May	May
8	March	April	June	June

Notes made during the growth seasons of 1914 and 1915 showed uniformity of growth. No noticeable differences separated the growth of the winter pruned trees from the growth of the spring pruned trees. Because of the apparent uniformity of growth, some way to roughly indicate any lack of vigor was sought. In this preliminary study, particularly in view of the make-up of the orchard, it was not considered desirable to undertake extensive measurements. The longest shoot growth of the season was finally selected as a rough means of showing, not comparative vigor, but *lack of vigor*. The longest shoots in each row were measured, taking at least one shoot to the tree. This index obviously would not be satisfactory in a comparison of the season of pruning dealing with standard varieties planted in blocks. However, there were so many variables involved under the conditions of this preliminary work that it was considered as reliable as any other method would have been. Table II is a comparison of these longest shoots for the growing seasons of 1916 and 1917.

TABLE II
Comparative Length and Butt Diameter¹ of Longest Shoots from the Month-Rows

Month	Growth of 1916 Trees Pruned 1915-1916 Average of 6 Longest Shoots		Growth of 1917 Trees Pruned 1916-1917 Average of 10 Longest Shoots	
	Length in Centimeters	Diameter in Millimeters	Length in Centimeters	Diameter in Millimeters
November	95.4	7.9	93.6	8.9
December	98.3	8.2	101.5	9.3
January	99.9	8.9	105.7	9.0
February	115.1	8.9	98.8	8.8
March	106.3	7.9	83.3	8.4
April	104.0	8.7	91.0	9.9
May	76.8	6.8	81.1	8.7
June	44.3	4.8	89.0	8.3

¹Diameter taken 1 cm. above bud scars, avoiding buds.

From the table it will be seen that the shoot growth of 1916 from fall and winter pruning was slightly less than the shoot growth from spring pruning (excluding May and June). The shoot growth

of 1917 shows exactly the opposite development. The 1916 growth followed the last general heading back of the shoots. The trees pruned in May and June were pushing new growth rapidly, and since much of this new growth was at the tips of the older shoots it was lost in the heading back process. This accounts for the reduction in shoot length for these months. In the following year the pruning was largely thinning of the shoots without heading back, and the resulting growth for May and June compares favorably with the growth for the other months. In general, Table II shows that there was no detrimental effect upon growth chargeable to pruning in the late fall or in the winter under northern conditions.

Considering the maturity of shoots, no difference could be noted. If the trees held their leaves late, they did so uniformly. If the shoots showed browning of the wood from winter injury, this too was uniform for all pruning seasons. In the healing of wounds no difference could be detected which could be charged to seasonal effect, although when the wood was frozen the use of lopping shears often produced a splintered wound and torn bark in excess of normal.

Comparing the amount of dying back of the tips of shoots, it was noted after the 1915-16 pruning that this dying was fairly uniform, no matter in what month the work was done. It was no more severe from fall and winter pruning than from spring pruning, or even from June pruning.

The conclusions to be drawn from these observations are that pruning in fall or winter in Minnesota is not detrimental to tree vigor, maturity of shoots, hardness of growth or wound healing, and that the tips of shoots pruned in the fall and winter do not die back more than the tips of shoots pruned at other times. Apparently the apple grower in Minnesota can prune at a time most convenient for him, just as growers to the East, South, and West are doing.

Opportunity has been found within the past season to continue these studies in four representative orchards which will give an opportunity to work with a much larger number of trees and with common varieties such as Wealthy and Oldenburg. Conclusions to be drawn from the work in these orchards should be much more dependable than the conclusions from these preliminary studies, but the lack of marked seasonal effects in the preliminary work is of interest.

Growth and Yield of Apple Trees

By N. L. PARTRIDGE, *Delaware Experiment Station, Newark, Delaware*

THE present paper is merely a preliminary report of some results secured in the experimental apple orchard of the Delaware College Agricultural Experiment Station at Newark, Delaware. The speaker desires to acknowledge the assistance and council given to him by Prof. C. A. McCue of the Department of Horticulture and Dr. Lamkey of the Department of Plant Physiology of Delaware College.

The orchard in question has now completed its tenth season's growth, and all the varieties mentioned herein have produced fruit in six seasons. The yield is increasing year by year and the trees have not approached their maximum in any variety, the crop of 1919 being the largest obtained to date. The growth measurements are obtained by measuring the circumference of each tree at a nail driven in the trunk about a foot above the ground. The yield is obtained by weighing the fruit and the figures given herewith include both picked fruit and drops.

The trees discussed are a portion of the trees growing on the apple fertilizer plots and are, therefore, subjected to very different treatments on the different plots. Although some of the varieties of apples in this block are omitted, no tree of the varieties discussed has been omitted from the calculations unless it has been removed from the orchard during the progress of the experiment or planted at a more recent date than the balance of the trees. There is a certain amount of crown gall in this orchard which appears to be quite significant in the growth and yield of the individuals affected. However, these trees are included as a complete census of the diseased trees has not been made.

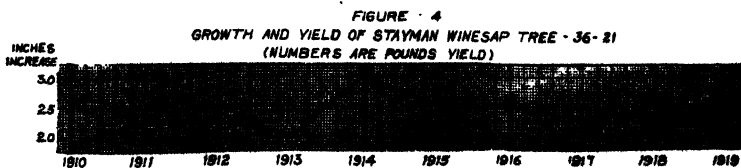
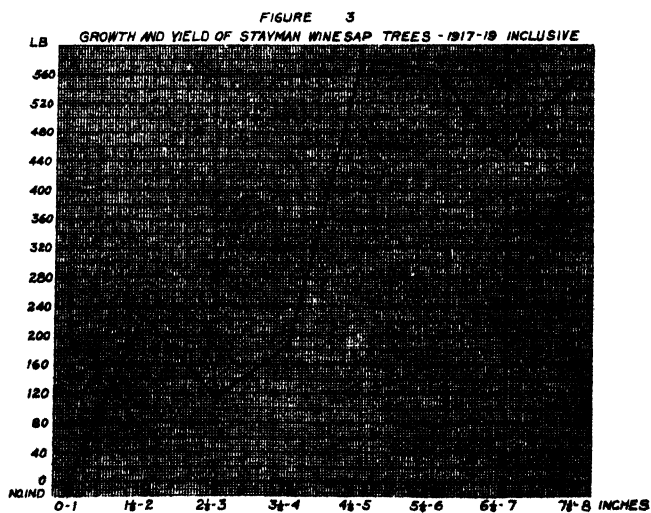
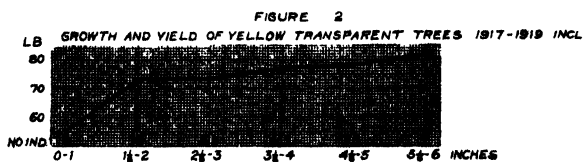
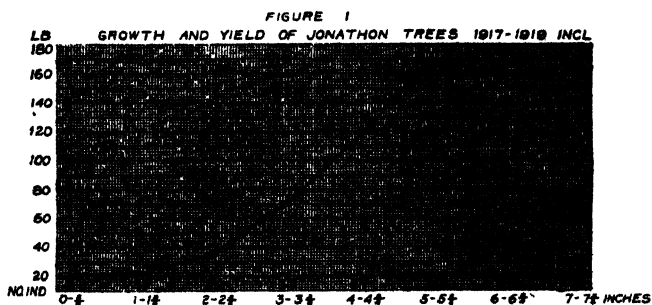
The records of this orchard show that there are very considerable differences in the yield of the different apple trees in the orchard. A similar variation was found to occur in the growth that the different trees were making. Although the difference in the growth and yield of individual trees in a fertilizer experiment are probably greater than in an orchard receiving uniform treatment, still similar differences are characteristic of the most uniform of orchards. This is apparent to anyone who has noticed the wide variation of results obtained on trees growing on a small uniform experimental plot.

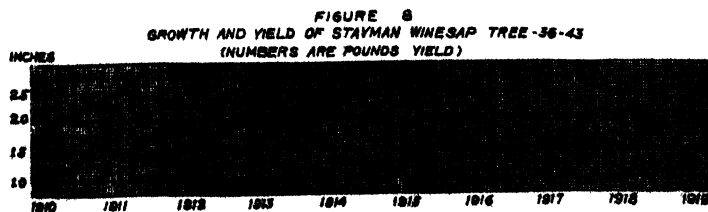
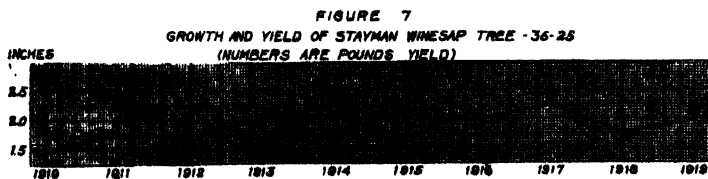
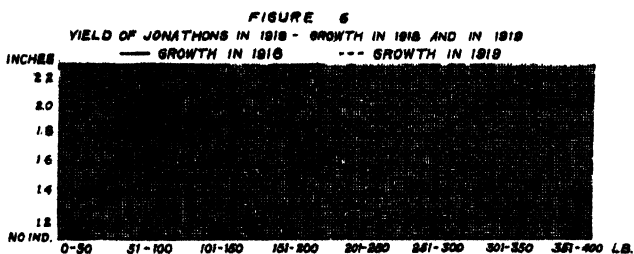
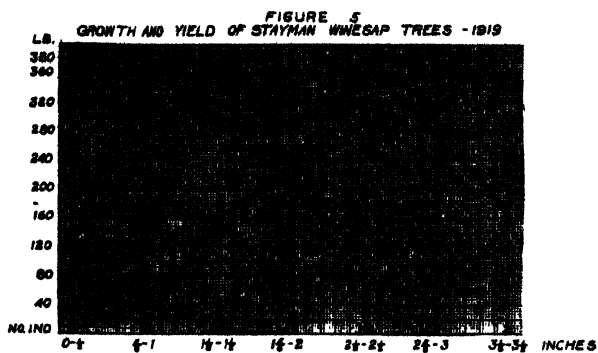
This paper is an endeavor to find out what relations, if any, exist between the growth and yield of Jonathan, Yellow Transparent, and Stayman Winesap trees growing under the conditions mentioned above. It should be borne in mind that the trees are still young and have not developed settled bearing habits and that there is a wide deviation in the amount of fruit borne by trees making the same amount of growth in a stated period. However, even though positive conclusions are premature, indications of the relation between these two functions of a tree are pronounced.

The ordinates of Figure 1, show the average number of pounds of fruit yielded by the Jonathan trees during the years 1917 to 1919, inclusive. The abscissa represent increase in circumference of the trees during the same period. It will be noticed that the average yield per tree increases as the amount of growth during this period increases.

The same statistics for the Yellow Transparent trees are shown in Figure 2, and the type of curve is seen to be similar.

The same data in regard to the performance of the Stayman Winesap trees are shown in Figure 3. This curve is seen to be much more irregular than the two preceding ones. This roughness is probably due to the smaller number of individuals available in calculating the averages which are plotted.





These three figures indicate most strongly that there is a very constant relationship between the growth that the tree has made and the amount of fruit that it has produced during this three year period. There was a slight indication of a possible optimum amount of growth in the graph of the Jonathan trees, and again in the case of the Stayman Winesaps. However, the limited number of individuals making the comparatively very large growths was so small that a conclusion is unjustified. The indication should not be ignored, however, and observations should be made to find if this tendency is maintained in the future.

The optimum relation between growth and yield indicated in Figure 3 is more pronounced in the data plotted in Figure 5 which shows the average amount of fruit yielded in 1919 by the Stayman Winesap trees. The abscissa represent the amount of growth made by the trees in 1918, and the ordinates show the average yield in each case. While an optimum growth is very evident in the graph, it should be noticed that the numbers of individuals upon which it is based is small, and the probable errors of the means of each class plotted are therefore comparatively large. It does, however, furnish a significant indication of what may be normal to apple trees and further observations upon this point are needed.

In order to show whether the growth of the present year or that of the preceding year is the most significant in relation to this year's yield, Figure 6, was made.

The abscissa of Figure 6 represent the number of pounds of fruit yielded by Jonathan trees in 1919. The ordinates represent the average growth made by each class of trees: the solid line of the graph the average performance of each class in 1918, and the dotted line, in 1919. It will be observed that the solid line shows a steady increase of both growth and yield up to the class which were yielding 151 to 200 pounds in 1919. This relation is not so obvious in the dotted line representing growth made this year. In other words, the growth made the previous year is more significant in relation to this year's yield than is the growth made this year. The falling off in the solid line after the 151 to 200 pound yield may be due to either the optimum effect mentioned above, or to the larger variation probable in locating the mean of a smaller number of individuals.

The trees in this orchard are young. The trees of none of the varieties have become firmly established in their regular biennial bearing habit. So far the trees have fallen into three natural classes: 1, those which have a tendency to bear heavier in the odd year than in the even; 2, those which have a tendency to bear more in the even year than in the odd; 3, those which have made a consistent increase in yield each year to date, with perhaps a few irregularities, but with no consistent biennial tendency indicated. There are also a few trees which are uniformly making a very small growth due to crown gall infection, or to undetermined unfavorable conditions, that are making only a small yield and which are either remaining stationary or actually decreasing in yield.

The annual increase in trunk circumference and the weight of fruit borne by a tree bearing in the even year is shown in Figure 7.

The same data for a tree bearing in the odd year is shown in Figure 8. Figure 4 shows the data for a consistently increasing yield.

There are a few interesting observations to be made in regard to these trees. During the years 1917 and 1918, if the growth made in a given year is smaller than that made the previous year, the yield that year is larger. And the reverse is equally true. If the growth made in a given year is larger than that made the previous year, the yield that year is smaller. In other words there is an alternate habit of growth as well as an alternate habit of bearing in these trees. However, in the case of the tree with an increasing yield, this is not the case. The fluctuations of growth are less marked than in the case of the tree in which the alternate habit is becoming established; and where the slightly decreased growth that is recorded for 1917 is made, it is followed by an increased rather than a decreased yield. The fact that the five Stayman Winesap trees that have produced the most fruit per tree belong to this latter class indicates that this class of trees is composed of the most vigorous trees of the variety in the orchard. They have reached the point where the large crop of fruit produced this year was sufficient to depress the growth of the tree somewhat this year, and the indications are that these trees will now fall into the biennial habit of bearing and growth, making their larger growth in the even numbered years and their heavier fruit production in the odd numbered years.

As a general proposition, though with exceptions, the trees that are establishing the alternate bearing habit in the odd numbered years rank next in total production of fruit to date. They are not making as strong a growth as the trees of the class just mentioned and reached the point where the amount of fruit produced in 1917 was sufficient to cut down the growth made that season. The result that followed was a reduced yield and a consequently increased growth the next year. Thus the biennial habit has become established with them.

It is more difficult to determine the exact cause for the trees with a biennial habit of bearing in the even numbered years. As a general thing the crop produced in 1916 was not a conspicuously large one and that cannot be advanced as a reason for the habit. The only point that seems to be common to these trees is that they are the lowest bearing trees of the three groups mentioned.

In closing it should be noted that while there are not sufficient data to explain the causes for certain of the relations that exist between growth and yield, sufficient facts have been offered to show that such a relationship does exist.

The Status of Orchard Fertilization Experimentation

By W. H. ALDERMAN, *University Farm, St. Paul, Minnesota*

MOST of us are pretty well acquainted with our old friend, the "fertilizer experiment", with its familiar "plot series" of single and combined elements and checks. Sometimes it is dished up with a new dressing, garnished tastefully and served under a new name but the main ingredients remain the same. It has been a

favorite dish among horticulturists for thirty years and most of us have stuck pretty closely to the same tried and well tested recipe in its preparation.

The horticulturists of about 28 experiment stations in the United States and Canada are giving some attention to the orchard fertilizer question. This seemed to be an unduly large number to be working upon one problem, especially if the most of them were operating along the usual line. To bring together some information upon this point, letters of inquiry were sent to those known to be especially interested in orchard nutrition problems. The primary object of the inquiry was to find out whether in the opinion of the workers they were getting anywhere with the problem with present methods and what in their judgment should be the future line of attack. Practically every man replied, a point worthy of comment. Their courtesy and interest in the matter is appreciatively acknowledged at this point. The writer wishes it were possible to present in full the many interesting replies, but as this is out of the question it will be necessary to confine the discussion to the barest summary of opinions and viewpoints. This paper is an attempt to present these points of view in a composite form which does not involve a compromise of issues.

The most striking feature of the replies was the almost complete unanimity of opinion that from the standpoint of research the old type of orchard fertilizer experiment had about outlived its usefulness. There was only one dissenting opinion on this point. This does not mean that the former type of project should be cast aside entirely, for they will always be valuable as tests or demonstrations of localized nature. One horticulturist well expressed the general thought when he said, "There are sufficient field experiments now under way in the different experiment stations to solve the problem of orchard nutrition so far as it may be solved from field experiments."

This seems to be a suitable occasion to pause and consider the work that has been accomplished to date. Within the past two years a number of well conducted experiments extending over long terms of years have matured, and the results been made public. So much has been written on the subject that it is a bit difficult to summarize the case, since the evidence does not all point in the same direction. It is somewhat simpler if we first confine ourselves to the points over which there is seemingly no contention.

1st. There are apparently a great many orchards growing upon a wide variety of soils that will not respond economically to the application of any form of commercial fertilizer, nor of manure. This fact is well established by the work in New York, New Hampshire, Maine, West Virginia, and other states.

2d. Orchards are much more likely to respond favorably if they are given sod mulch treatment than if kept under cultivation. A comparison of the work in the above mentioned states with that in Massachusetts and Ohio, furnish interesting evidence upon this point, as does also the work in Pennsylvania where the three sod orchards displayed considerably greater gains than the three under cultivation.

3d. Orchards under starvation conditions usually give a ready response to fertilization when other treatments (culture, pruning, spraying, etc.) remain unaltered. This is well demonstrated by some of the Ohio, Oregon and West Virginia experiments.

4th. Nitrogen in a readily available form seems to be the only element of plant food that is uniformly a factor in the favorable responses—when such are secured.

These four points, apparently, are about the only outstanding, uncontested results of our orchard fertilizer experiments conducted over a period of thirty years or more by twenty-eight different experiment stations. This information is of no small value to the orchard industry and has been well worth working for, but the investigator who is seeking to understand the "how" and "why" of the reactions finds only disappointment. There have been those among us who have thought and talked of principles that underlie orchard fertilization, but so far no principles have been formulated which are capable of application. There are others—probably the majority—who have maintained that orchard fertilization cannot be reduced to general principles having a wide application. So far this group has not been disappointed.

It seems that the difficulties thus far have been in a large measure due to the horticulturist's failure to correctly estimate the differences between trees or orchard plants and the annual plants of our ordinary field crops. In the latter it has been comparatively easy to study plant food requirements and locate certain definite "limiting factors," for there are remarkably few cultural variations to complicate the results. With orchards we have an entirely different situation. We have already shown that trees respond differently to fertilizers under different cultural treatments. So great is the difference that under cultivation they may make no response whatever, while under sod treatment they may be remarkably stimulated by fertilization. In other words, the cultivation may, in some instances, have produced the same effect as the addition of fertilizers. We might carry the analogy still farther and show that in certain cases, where old and enfeebled trees are involved, the same stimulating growth and fruitage effects may have been caused by nitrogen feeding or by a suitable pruning. We are leading to the point where we may readily see and safely say that a normal plant probably has a definite arrangement of conditions within itself which fit into its functions of growth and fruitage or reproduction. It is when the arrangement is disturbed that we get reduced vigor, feeble growth or lack of productiveness. Our mistake in the past was to establish various sets of experiments to correct the condition, perhaps with fertilizers, perhaps with sod and tillage studies, perhaps with pruning. Our mistake lay in failing to see that all of these methods lead over different routes to the same goal, namely, the restoration of a normal or an optimum arrangement of the forces within the plant. We attempted to study the effects of fertility, culture, and pruning separately and overlooked their close interrelationships, and the fact that all contributed more or less to the establishment of the desired condition within the tree. A clear understanding of this might have helped to explain some of the inconsistencies of past fertilizer

experiments. It may be recalled that in the Pennsylvania experiments the orchard having the least fertile soil responded the least to the addition of plant food materials. Evidently the equilibrium of the trees was being maintained by some other method.

All this seems to carry our problem into the inside of the tree rather than into the soil or other external factors. Of course, our minds are forced into this channel by the remarkably significant work of Kraus and Kraybill with the tomato. They clearly demonstrated that there was a certain balance between nitrates and carbohydrates in a plant when optimum fruiting conditions prevailed, and that, when this balance was disturbed, failure to fruit was the result. It is conceivable and probable that the same, or a similar balance, must prevail in other plants. It is likely too, that other factors will be found which relate to this balance. We at once think of the moisture factor in this connection. The storage of nitrates and carbohydrates varies with the season of the year. What relation does this fact bear to the afore-mentioned balance? The studies of Dr. Hooker within the past year are strongly indicative of suspected differences in the metabolism of productive and non-productive trees. These differences, when finally definitely established, will furnish the foundation for an intelligent field study of the broad problems of orchard nutrition. In these future studies we will change our point of view. Instead of applying treatment after treatment to a number of orchards under a variety of conditions in, "now bear, darn ye" attitude of mind, we will first study the trees in an endeavor to diagnose their conditions and then make an attempt to adequately and intelligently discover a treatment for their conditions. This treatment may very likely involve pruning and orchard culture, as well as plant food material, for it will be a broad problem of orchard nutrition. Kraus has already pointed out that we may establish a proper balance in a tree low in nitrates by feeding with nitrogen, or by pruning to reduce the supply and production of carbohydrates.

If our problem has led us to a study of the inside of the tree it is quite clear that it has inevitably led us, temporarily at least, from the orchard into the laboratory. If we are to become better informed regarding the metabolism of the apple and other fruit trees we must look to the man trained in chemistry and plant physiology to tell us. Many of our younger horticulturists are wisely equipping themselves with this training, but most of us must rely either upon a cooperative arrangement with the departments of chemistry and botany, or establish within our own departments the necessary laboratories and workers in these lines. Most of those to whom the letter of inquiry was sent favored the use of the men and laboratories of the other departments because of the expense of installing such additions to the horticultural equipment. Whichever of the plans is followed makes very little difference and depends upon local conditions entirely. The important point is that the horticulturist must not lose his present intimate contact with the problem, for his knowledge of orchard details, of the care of the tree, his point of view, and his tendency to seek a practical application for such scientific discoveries as may be made, are absolutely indispensable.

There will be many in the next few years who will reach this problem from different avenues of approach. Laboratory methods will largely prevail and necessarily small numbers of trees will be involved. In many instances these trees will be grown in pots or lysimeters. It is hardly necessary to point out that under these conditions it is of the greatest importance to reduce individual plant variation to a minimum. Possibly in orchards the greatest variables are the trees themselves. In the first place, they are propagated upon seedling roots which we know are variable. Just now, when seeds from all manner of sources are being used, this variability becomes extreme. If allowed to develop, some of these seedlings would be far more vigorous than others, some in fact would be dwarfs. How great would be the influence of these variable roots upon the scion top is unknown. No attention is paid to the selection of buds or scions, a matter which may or may not be of much importance, but which should be safe-guarded for experimental work. In short, before launching a project of this nature every effort should be made to secure specially propagated trees that are as nearly alike as is possible to secure. Trees of a given variety on their own roots would be similar, both genetically and physically, but they would represent a type which might differ in some respects from a budded or grafted tree. A more desirable plan of operation would be to work buds or scions from a single parent tree upon root stocks developed by cuttings, or other means of asexual propagation from a single parent plant. This would give us a plant comparable in its physical aspects with the ordinary nursery tree of commerce and of which a series would be uniform enough for purposes of research.

In conclusion, if your thoughts are correctly interpreted from your correspondence, let me remind you that to research men the old "fertilizer project" is about to become of historical interest only, and in its place comes the "nutrition project", broader in its scope, more fundamental in its direction, and more exacting in its requirements of men and equipment. Do not misunderstand this statement. The old "fertilizer experiment" will not be dropped, but will be renamed and reclassified so that it may be placed in its proper genus, "demonstration", belonging to the family, "extension", where it performs a most important service when "introduced" by the extension specialist into new habitats, and when its "range" is extended to the county agent who will be associated with it in rural communities or on individual farms.

Methods of Interpreting Results in Orchard Fertilizer Experiments

By R. D. ANTHONY, *Pennsylvania State College, State College, Pa.*

OUR present knowledge of how best to lay out a fertilizer experiment is none too substantial and little of this was available to the men who started the experiments which have now been completed or are still under way. It is safe to say that no one of our fertilizer

experiments is ideal or even approaches at all close to that condition. Because of this, the task of interpreting our results is difficult. The difficulty is increased because, for many reasons, it is seldom possible to use the methods which have been developed by our agronomy friends without considerable modification. The agronomist deals with such large numbers that the individual is seldom considered; in our work the performance of the individual is everything. The agronomist usually follows a plant through its full life cycle; the longest continued orchard fertilizer experiment in this country covers only a small part of the possible life of the orchard. Field crops are usually influenced more by surface soils; tree fruits by sub-soils.

Even though we admit the necessity of improving our methods of presentation and interpretation in order to get the most out of our fertilizer experiments, we should not go to the other extreme and seek to develop standard methods. The conditions surrounding no two experiments are alike; each set of conditions demands a different method of presentation. Our study should be to find the various methods which might be used and then to make a wise choice of those best adapted to our conditions.

In this article, it is not the speaker's intention to outline all the methods which might be of value, but to give only those which he has found of value in his own work.

Wide latitude should be given the investigator in the choice of methods. The question is sometimes raised as to whether or not he should be permitted to use weighted values. No one knows the conditions surrounding an experiment better than the investigator should, and so long as he presents the original, uncorrected values and gives adequate reasons for his modifications, the use of weighted results might well be part of the interpretation. To present such modified results without explaining the method used or giving the original values (a thing that has been done a number of times) may destroy the value of the experiment.

One of the factors which can always be depended on to add confusion to recorded fertilizer yields is that of alternate bearing. The writer of a bulletin published some time ago used nearly half a page wondering why, after his fertilizer plots had responded so well the first year, they should drop below the check plots the second year. If the yields were always in two-year cycles the problem would be simpler, but occasionally the cycle is three or four years. The record of the rank of the highest yielding plot for eleven years, in one of our Pennsylvania fertilizer experiments, is as follows: 2, 3, 3, 1, 12, 2, 3, 1, 12, 1, 8. We have found a satisfactory solution of this difficulty by using four-year, overlapping averages. If the experiment began in 1908 the first value used is the average of the yield from 1908 through 1911; the next, for the years from 1909 through 1912, etc. This method smooths out the yield curves and makes it far easier to compare the records of different plots.

No small part of the confusion which seems to exist in our orchard fertilizer experiments is due to our failure to emphasize the cultural treatment given the various orchards. The accumulated data

compels us to believe that cultural treatment has a profound influence on the returns secured from fertilizer applications. We may expect, with considerable confidence, to get our money's worth from fertilizers in a sod orchard, but the same application under nearly identical conditions in a cultivated orchard will rarely show a profitable return. If we can apply the results secured by Pickering at the Woburn Station in England to American conditions, we possibly have the explanation for the failure of one of the tillage experiments in New York to give the usual results in favor of tillage. In the cultivated plot, a strip of sod several feet wide was left between the trees in the direction of the row. According to Pickering, this amount of sod was sufficient to have an important effect upon the results. If this was the case in a cultural method experiment, it would seem reasonable to expect similar conditions to affect a fertilizer experiment even to a greater extent, yet apparently minor details such as these are seldom discussed in our bulletins.

In our eastern orchards, it is seldom possible to lay out a fertilizer experiment on land that is entirely level or where all the plots have the same uniform slope. A study of the topography of the orchard sometimes shows the reason for certain unexpected results. In one of our Pennsylvania orchards, one check plot was considerably higher in yield than the five other checks. A study of the slope of the land showed much of this plot to be in a low area where washing from a rather steep slope had taken place. This same condition had increased the adjoining plot when manure was applied and made this treatment show a greater return than should probably be assigned to it. The repetition of the checks gives us a guide as to the extent of increase in the check plot, but, because the treatment plots were not repeated, we can do little more with the manure plot than to assume that it was increased by the same amount that the high check was increased over nearby checks. It would seem well worth while to incorporate detailed topographic notes or a topographic map in all fertilizer experiments even though at the time, topography does not seem an influential factor.

Along with variations in elevation go soil variations. In most reports this point is discussed, but not always in such a way as to throw light on the data. In a bulletin published four or five years ago, which is admirably written in most respects, the investigator describes a soil change at the northwest end of the orchard and then apparently has neglected to show on the chart of the orchard which end is north-west.

It is not always easy to detect subsoil variations from a study of the surface soil. A chart of the orchard which shows the performance of each tree will sometimes lead one to suspect a subsoil variation which can later be verified with the soil auger.

Table I gives the total yield of pounds of each tree in the Rome Beauty orchard discussed in Geneva Bulletin 460. The two trees in Plots II and III that are in Row 1, are in an area with a sandy subsoil. The trees in Plots X, XI, and XII, that are in Rows 9 and 10, are in an area with a clay subsoil. These differences probably account for the extreme differences in yield.

TABLE I
Total Yield in Pounds

Plot	Row Numbers					Plot	Row Numbers				
	1	2	3	4	5		7	8	9	10	11
I...	4900	4900	5600	3700	5100	VII	(Discarded)				
II...	3400	5000	5300	4300	4900	VIII	4200	2800	5200	3100	3400
III...	2600	4700	4900	5100	6100	IX	4700	4000	4100	3800	3700
IV...	6500	5600	5400	2800	5400	X	5700	4200	5300	5000	3200
V...	3800	4000	4700	3300	4000	XI	2400	3100	5500	6000	4800
VI...	5400	4600	4100	6800	4100	XII	4300	2700	5400	6300	3200

Many of our older fertilizer orchards were planned without buffer rows and with the trees planted so close to each other that cross feeding has become a matter of some importance, and in this connection the treatment of adjoining rows not in the experiment should be noted. In one of our experiments the first row was a check row and was higher in yield than other nearby checks. This is certainly due to the heavy fertilization given the adjacent row by the owner of the orchard, the men not being careful to avoid scattering some of the fertilizer beyond the middle of the row. Minor details such as these are well worth noting as they may influence the results to a surprising extreme.

Many of our present fertilizer experiments were laid out under belief that the performance of a single element could be told by subtracting the yield of a two-element plot from that of a three-element plot. There is considerable doubt as to the justification for such a method; in fact, there is some evidence that the increased yield for a single element may be either greater or less in combination than when used alone. Because of this, the conclusions from a number of experiments which are now under way cannot be made as definite as we might wish.

One of the most difficult factors to study is that of individual tree variations which can not be attributed to evident environmental conditions. We must expect a certain amount of fluctuation in our yields. Our problem is to attempt to find how much of our actual difference is due to normal individual variations and how much to our treatment. Agronomists came to realize the importance of this factor of probable error long before horticulturists did, though because of the small number of individuals we deal with, it is even more important with tree fruits than with field crops.

We should not consider the report of the yield of a fertilizer plot as complete until the probable error is computed nor in most cases should we consider the difference between two treatments as of any significance until we know the probable error of the difference. Tables showing the significance of the probable error can be found in a number of places. A convenient one to use is that published by Pearl and Miner in Bulletin 226 of the Maine Station. Another by Batchelor and Reid will be found in the *Journal of Agriculture Research*, Volume XII, No. 5.

Where we have all erred most frequently is probably in the use of check plots. Under many conditions, to use the average of the checks is very misleading. In the case of the orchard mentioned under the discussion of topography, if we use the average of all six checks as a criterion, the manure plot shows a gain of nearly a thousand pounds, more than twice the gain over the adjacent, high yielding check, though a study of the topography of the orchard leads us to believe that the proper comparison is with this adjacent check.

We have come to the conclusion that there is no one best method for the use of checks. In some parts of the orchard, the average of several checks may be used; in other places a nearby check needs greater emphasis or may even supply the only usable comparison. Several ways of using checks are outlined by Batchelor and Reid in the article previously referred to, which, by the way, is one of the most valuable contributions that has been made to our problem.

Unfortunately, when most of our present fertilizer experiments were planned, too much reliance was placed on the repetition of checks and usually the treatments were not repeated. A repeated treatment will frequently be of greater help than a repeated check.

In the previous discussion we have had in mind chiefly the interpretation of experiments now under way. Perhaps it will not be out of the way to call attention to a method which could be used in bearing orchards in starting new experiments to show, better than could be shown by many repeated checks, the underlying soil variations and the normal performance of our trees. Where an area has been selected for a fertilizer experiment and the arrangement of plots decided upon, do not begin the treatment until two, or better still, three crops have been harvested. Usually our most difficult problem in interpreting fertilizer experiments is to determine what share of our observed differences is due to inequalities which existed before the application of our fertilizer treatments. The performance of the trees for a crop cycle will throw much light on this.

How wide an application can we make of a single fertilizer experiment? At present we have not sufficiently definite information to answer this question, but one case will show our uncertainty. For over ten years the Pennsylvania Station has been conducting two experiments, one on each side of South Mountain, under somewhat similar conditions. In one of these there has been but little return, but in the other potash seems to be giving considerably increased yields.

Orchard fertilizer experiments are going out of fashion and certainly pomological research will be improved by the passing of the old type of experiment, but it will be unfortunate if the partial failure of these early experiments to give us conclusive results should discourage us from continuing such a fundamental line of investigation.

Some Influences of Thinning, Pollination, and Fruit Spur Growth on the Yearly Performance Record of Fruit Spurs and on the Size of Fruit Produced*

By E. C. AUCHTER, *Maryland State College, College Park, Md.*

IN THE spring of 1912 some apple thinning experiments were started by the Horticultural Department of the West Virginia Station to determine not only the influence of thinning the fruit on the present crop, but also the influence of the thinning on the following crop. Some of the results found have already been published†, but this report includes the data taken since the previous publication and brings the records up to date.

THE INFLUENCE OF FRUIT THINNING ON ANNUAL BEARING IN THE APPLE

As shown in the previous report, the removal after the June drop of part of the fruit from a tree bearing from a medium to a good sized crop, was profitable. Not only was the size of the individual apples increased, but the total yield per tree was also greater on the thinned trees due to this increased size of fruit. At that time the statement was made that thinning had not influenced the next year's crop to any extent. Additional data secured since that time and included in this report add more proof to this statement and substantiate our earlier findings and conclusions. The following tables show the yields secured from thinned and unthinned trees.

TABLE I

Yields on Thinned and Unthinned Trees of Eighteen Year Old Rome Beauty, York Imperial, and Baldwin. (Years 1912 and 1913)

Variety	Number of Trees	Yield per Tree in Bushels (1912)	Yield per Tree in Bushels (1913)
Rome Beauty	6 thinned	12	1
Rome Beauty	2 check	14	1
York Imperial	3 thinned	9	0
York Imperial	1 check	11	0
Baldwin	3 thinned	11.3	0
Baldwin	1 check	13.6	0

In 1912, 45 York Imperial trees ten years old, bearing their first good commercial crops, were thinned, while 9 similar trees were left as checks. Cedar rust broke out in this orchard badly this year

*The data presented in this paper were obtained by the writer while a member of the Horticultural Department of West Virginia Agricultural Experiment Station. The data during the present season were taken by Mr. H. L. Crane, Assistant Horticulturist at that Station. Permission to use the data in this paper was courteously given by Dr. J. K. Shaw, now Horticulturist at that Station.

†Auchter, E. C., W. Va. Agr. Exp. Sta. Bulletin 162.

and the York Imperial foliage being exceptionally susceptible, practically all fell from the trees early in the summer. Of course, no records were obtained, since the fruit on all trees ceased to develop. None of the fruits became larger than walnuts, which merely emphasized the fact that leaves and leaf area are essential for fruit development when the tree as a whole is considered. However, certain investigators have shown that the fruit developed almost normally on certain occasional spurs, which are defoliated only here and there on an otherwise normal tree.

TABLE II
Yields on Thinned and Unthinned Baldwin Trees, Nine Years Old in 1915

Variety	No. of Trees	Distance Thinned Inches	Average Yield per Tree in Bushels				
			1815	1916	1917	1918	1919*
Baldwin	5	6 to 7	2.88	0	1.40	.9	1.5
Baldwin	5	9 to 10	2.31	0	2.50	.2	2.0
Baldwin	3	Check	3.53	0	.92	1.0	1.3

*July estimate.

TABLE III
Individual Tree Records of Thinned and Unthinned York Imperial Trees, Eight Years Old in 1917

Variety	Tree No.	Distance Thinned Inches	Average Yield in Bushels		
			1917	1918	1919*
York Imperial	1	6 to 7	8.0	0.00	0.00
	2	6 to 7	6.0	0.00	0.50
	3	6 to 7	5.0	0.75	1.50
	4	6 to 7	6.5	0.12	1.00
	5	6 to 7	5.0	0.00	0.50
York Imperial	1	Check	7.0	0.00	0.25
	2	"	5.0	0.00	0.50
	3	"	7.0	0.00	3.00
	4	"	6.0	4.50	0.00
	5	"	6.0	1.50	0.25
	6	"	6.0	0.12	0.12

*July estimate.

TABLE IV
Average Yield in Bushels per Tree of Thinned and Unthinned Ben Davis Trees, Nineteen Years Old in 1914

Distance Thinned	No. of Trees	Average Yield per Tree in Bushels					
		1914	1915	1916	1917	1918	1919
3 to 4 inches	3	9.9	0	12.2	0.12	13.0	*
6 to 7	3	12.0	0	15.5	0.10	9.7	*
9 to 10	3	13.3	0	15.8	0.12	13.7	*
Check	3	12.7	0	17.3	0.20	12.9	*

*Practically nothing.

A study of the foregoing tables shows that those trees which had part of their crop removed after the June drop did not produce any

more fruit the following year than similar trees which had not been thinned. This held true for young or old trees and for different varieties. Thus they disprove the popular idea so often heard and printed in some horticultural journals that by thinning part of the fruit from a tree in its crop year, such trees will bear a fair crop the next year. Thinning has been advocated as a remedy for biennial bearers. Theoretically it has been held that if fruit is removed from certain spurs on a tree that such spurs will then form fruit buds rather than leaf buds and will thus bear the following year. By having part of the spurs on a tree bear one year and the other part the next year, all varieties would be annual bearers. Results of fruit spur studies shown a little later in this paper throw some light on the question and tend to explain why thinning does not make annual bearers from so-called biennial bearers.

THE INFLUENCE OF FRUIT THINNING ON THE SIZE OF FRUIT

Although the removal of part of the crop from an apple tree does not influence the next year's crop, still there is a noticeable influence on the size of the fruit during the year in which the thinning is done. The following tables illustrate this point.

TABLE V

Influence of Thinning on Size of Fruit. Ben Davis Nineteen Years Old (1914). Results Show the Totals for Three Trees in Each Case

Distance Thinned Inches	Total Number of Apples when Picked (3 Trees)	Total Yield in Bushels (3 Trees)	Marketable Yield (above 2¼ inches in Dime- ter)	Average Weight of Apples in Ounces
6 to 7	7,476	36.00	32.28	3.46
9 to 10	9,497	38.97	30.00	2.95
Check	12,476	38.02	13.00	2.16

TABLE VI

Influence of Thinning on Size (1916) Ben Davis Twenty-one Years Old. Results Show Totals for Three Trees in Each Case

Distance Thinned Inches	Total Number of Apples per Plot	Total Yields in Bushels per Plot	Marketable Yield (above 2¼ inches)	Per cent. of Crop Market- able	Average weight of Apples in ounces
6 to 7	8,669	46.38	31.06	66.97	3.85
9 to 10	8,711	47.55	32.07	67.43	3.93
Check	11,724	51.91	18.83	36.27	3.18

TABLE VII

Showing the Percentage of Fruit Removed at Thinning Time as Influencing Size and Annual Bearing. Ben Davis Twenty-one Years Old (1916). Figures are for the Average of Three Trees in Each Case

Distance Thinned Inches	Number of Apples per Tree After June Drop	Number Thinned off	Per cent Removed	Number Dropped During Sea- son Exclu- sive of June Drop	Number of Apples Picked at Thinning Time	Marketable Yield in Bushels per Tree (above 2¼ inches)
6 to 7 ...	5,111	1,196	23	1,025	2,890	10.35
9 to 10 ..	5,000	1,996	40	937	2,904	10.69
Check...	5,163	0	0	1,255	3,908	6.28

Tables V, VI, and VII show that the thinned trees produced not only larger specimens but about double the amount of marketable fruit. In Table VII we see that the number of fruits per tree was practically the same in all groups after the June drop. Although 23 per cent was removed per tree per plot in one case and 40 per cent per tree from another, still the remaining fruits increased in size so much that nearly double the marketable yield was obtained from the thinned trees. By referring to Table IV, it can be seen that the removal of this 40 per cent of the fruit on those trees thinned 9 to 10 inches apart, had no influence on the next year's crop. In fact, the check trees produced slightly more if anything. It can be seen also that these trees were bearing a fairly heavy crop (5½ barrels per tree in 1916) so that the effect of a 40 per cent removal of the crop ought to have shown up the next year if it is possible to affect the next crop by the removal of a portion of the present crop. Results shown a little later, tend to explain why the thinned trees did not bloom heavier the next year and bear more fruit than the checks.

FRUIT SPUR GROWTH AND FRUIT PRODUCTION AS INFLUENCING THE YEARLY PERFORMANCE RECORD OF SPURS

It can be seen from the preceding tables that considering the tree as a whole no influence from thinning was obtained. It was felt, however, that it would be wise to use the individual spur as a unit and get accurate yearly records on it. Accordingly, in 1916, all of the fruit spurs on a young 7 year old Delicious tree bearing a fair crop of fruit, were labeled, and a record of each spur obtained. The fruits from certain spurs were thinned while others were left unthinned.

In 1917 the fruit spur studies were greatly enlarged and 600 spurs each of Ben Davis, Grimes, Wagener, Baldwin, 500 spurs each of Northern Spy, Tompkins King, Rome Beauty, Smokehouse, 250 spurs of York Imperial, and 100 spurs each of Jonathan and Arkansas were included in the study. All trees were approximately 20 years old and were in a medium state of vigor, growing under sod mulch conditions.

At this time the scope of the problem was greatly enlarged and many different factors, such as the age of the spur, its yearly growth, its total length, blooming records, number of leaves, total leaf area, etc., were studied. It was hoped by this study to throw some light if possible on the factors which influence the yearly performance record of fruit spurs and by this knowledge to be able to make some recommendation to practical growers, which might increase their crop production.

These studies have now been under way for the years 1917, 1918, and 1919, all too short a period, to attempt any definite conclusions even if the mass of data, which has accumulated in this time, was thoroughly digested. Let me hasten to add that this part of the paper is simply a preliminary report and the data presented should be taken as suggestive rather than final. and a blooming record of the varieties for the three years, 1917, 1918, and 1919, shows that there is a considerable variation among the varieties in regard

TABLE VIII
Showing the Blooming Record of Ten Apple Varieties for the Years 1917, 1918, 1919

Year	500 Rome Beauty		600 Ben Davis		600 Baldwin		500 Tompkins King		500 Northern Spy		500 Smoke- House		100 Jonathan		100 Arkansas		469 Wagner		525 Grimes				
	1917	1918	1919	Number of Spurs	Per cent Blooming	Number of Spurs	Per cent Blooming	Number of Spurs	Per cent Blooming	Number of Spurs	Per cent Blooming	Number of Spurs	Per cent Blooming	Number of Spurs	Per cent Blooming	Number of Spurs	Per cent Blooming	Number of Spurs	Per cent Blooming				
O*	O	O	O	78	15.6	20	3.33	335	55.80	90	18.00	167	33.4	40	8.0	39	39.0	26	26.0	13	3.0	90	17.100
O	O	O	O	6	1.2	36	6.00	48	8.00	150	30.00	21	4.2	13	2.6	0	0.0	6	6.0	43	9.0	3	.060
O	O	O	O	159	31.8	2	0.33	23	3.83	8	1.60	10	2.0	19	3.8	39	39.0	5	5.0	0	0.0	102	19.400
O	O	O	O	27	5.4	0	0.00	2	0.33	3	0.06	0	0.0	22	4.4	2	2.0	5	5.0	0	0.0	0	0.000
B	B	B	B	100	20.0	179	29.80	161	26.80	108	21.60	247	49.4	128	25.6	18	18.0	23	23.0	173	37.0	168	32.000
B	B	B	B	45	9.0	8	1.33	0	0.00	5	1.00	0	0.0	143	28.6	2	2.0	7	7.0	0	0.0	162	31.000
B	B	B	B	25	5.0	4	0.66	0	0.00	1	0.02	0	0.0	87	17.4	0	0.0	0	0.0	0	0.0	0	0.000
B	B	B	B	60	12.0	351	58.50	31	5.16	135	27.00	55	11.0	48	9.6	0	0.0	26	26.0	240	51.0	1	0.002

*B—Spurs blossomed. O—Spurs did not blossom.

to the regularity of blooming. Thus, with the Baldwin, Northern Spy, and Wagener, none of the spurs studied bloomed in succession either in the years 1917-18 or 1918-19, and no spurs bloomed three years in succession. Only 12 Ben Davis spurs and 9 of the Tompkins King bloomed two years in succession and these were not all during the same two-year period. On the other hand, 97 of the Rome Beauty, 168 of the Grimes, and 252 of the Smokehouse bloomed 2 years in succession, but in this case also, not all of the spurs were blooming successively in the same two-year period as seen in Table VIII. This would indicate, if we went no farther with the study, that the first group were biennial in bearing habit, while those of the second group were perhaps inclined to be more or less annual in bearing habits. I might add that practical observation in commercial orchards tends to bear out this suggestion in most cases. It is suggested later, however, that the same spur seldom fruits 2 years in succession. Thus in the case of the biennial bearers, it appears as though nearly all spurs on the trees bloom and that most of these set until the June drop at least and then do not bloom the next year, while with the annual bearers, many of the spurs either do not bloom, or if they do bloom, they do not set and thus the same spurs bloom again the next year. There are other interesting results brought out in Table VIII which are not pertinent, however, in this phase of the question, so are not discussed.

THE VALUE OF FRUITING AS WELL AS BLOOMING RECORDS OF FRUIT SPURS

There has always been a question as to whether the annual bearers were annual bearers because the spurs on such trees were able to bear 2 years in succession, while the spurs on biennial bearers were unable to do this. From the preceding data, that the spurs on some varieties of the annual bearers bloomed successively while those on the biennial bearers did not, we might believe that this was the case. However, the following figures show that this is not necessarily true and that not only the blooming record of a spur must be known, but its fruiting record as well.

1. Of the 525 labeled spurs on the Grimes tree, 168 bloomed in each of the years 1917 and 1918, but only 4 of these had fruited in 1917.
2. Fifty-four Rome Beauty spurs bloomed in both 1917 and 1918, but only 8 of these had fruited in 1917.
3. Fifty-three Rome Beauty spurs bloomed in both 1918 and 1919, but only 5 of these had fruited in 1918.
4. Of 117 spurs of the 7-year old Delicious tree that fruited in 1916, only 7 bloomed in 1917.
5. Of 224 spurs of the Delicious tree that fruited in 1917, only 12 bloomed in 1918.
6. Of 113 spurs of the Delicious tree that fruited in 1918, only 10 bloomed in 1919.
7. On the other hand, 101 spurs bloomed in both the years 1917 and 1918.
8. and 200 spurs bloomed in both the years 1918 and 1919 on this Delicious tree.

Thus, these figures indicate strongly that if the bloom on a spur once sets fruit, such spurs will rarely bloom the next year. However, if the bloom does not set, then such spurs are liable to bloom the next year, if the tree is healthy and vigorous.

In practice, this is what often happens when all the blooms on a tree are destroyed by freezes or a frost. Such trees, even if biennial bearers, generally bloom heavy again the next year, and the off year has thus been changed. It is a fact, too, that such spurs would be more vigorous and probably make more growth as a result of the loss of the crop. This would tend to have them bloom again.

These results indicate then that most of the spurs do not bear 2 years in succession. They tend to disprove the suggestion that certain varieties are annual bearers because the spurs on such trees bear 2 years in succession.

General observation, however, shows us that all varieties do not have the same general type of growth. For instance, omitting the question of fruit spurs, both the Rome Beauty and Smokehouse are inclined to bear terminally on slender growths, and while the fruit is maturing, a side growth generally develops which often sets a fruit bud on its terminal again and bears the following year. Thus, in the case of these 2 varieties, considerable fruit is borne each year without reference to the fruit spurs. In fact enough fruit is generally borne in this manner to account for the varieties being classed as annual bearers. On the other hand, varieties such as the Yellow Transparent and Ben Davis often produce enough fruit terminally each year, especially when young, to be considered by many in the class of annual bearers. Other varieties, such as Wealthy, Wagener, Oldenburg, Jonathan, and some others, often form enough lateral fruit buds on one-year old wood to be considered annual bearers in some sections.

With reference to fruit spurs, it is possible that certain varieties normally produce more fruit spurs yearly than others, and in such cases, with more spurs to come into fruit each year, such varieties would be more liable to produce some fruit each year. In such cases, however, the same spurs would not bear regularly as explained above.

Many of the so-called annual bearers, however, do not bear by any of the above described methods and a different explanation of their annual bearing must be sought. A suggested explanation is given a little later in this report.

These results with fruit spurs mentioned above, if they hold true, after the data are compiled for the other ten varieties, seem to explain why the thinning of fruit after the June drop will not cause the thinned spurs to bloom the next year. It will be remembered that thinning did not influence the next year's crop on the trees, where the tree was taken as a unit. When certain individual spurs were studied, thinning likewise showed only a negative influence as affecting the next year's blooms.

Of 14 Grimes spurs thinned in 1917, 2 bloomed in 1918.

Of 64 Grimes spurs thinned in 1918, 0 bloomed in 1919.

Of 22 Ben Davis spurs thinned in 1917, 0 bloomed in 1918.

Of 25 Northern Spy spurs thinned in 1917, 0 bloomed in 1918.

Of 88 Delicious spurs thinned in 1917, 10 bloomed in 1918

Of 10 Delicious spurs thinned in 1918, 0 bloomed in 1919.

Thus it appears that inasmuch as the thinned spurs had set fruit before the date of thinning, the thinning was then unable to cause them to bloom again the next year. In the group of 88 Delicious spurs which were thinned in 1917, it will be noticed that 10 spurs did bloom again in 1918. In nearly every one of these cases, however, it was noticed that such spurs had made an unusually vigorous long growth and had generally set a terminal fruit bud on this growth. They were really abnormal spurs.

The preceding data suggest, however, that if the thinning was done before the fruit set, at blossoming time, that many of the spurs would then bloom again the following year. Experiments to test this point were started last spring and the coming spring will show us whether the above suggestion is well founded.

SOME FACTORS INFLUENCING ANNUAL BLOOMING OF FRUIT SPURS

The fact remains that a great many spurs on the same tree bloom 2 years in succession, while others bloom one year and not the next. In order to see if certain growth factors could be correlated with this fact, several spurs on the Grimes and Rome Beauty trees were studied for the years 1917 and 1918.

In the first place, all spurs which bore fruit in 1917 were eliminated from the study, thus doing away with this complicating factor.

One hundred Grimes spurs which bloomed in both the years 1917 and 1918, and 84 Grimes spurs which bloomed in 1917 but did not bloom in 1918, were selected and the following data summarized for the 2 groups of spurs:—Length of yearly growth in 1917, leaf area in 1917, total length of spurs, average length of 1916 and 1917 growth, number of leaves per spur in 1917, and age of spurs. The following results were obtained.

TABLE IX
Growth Records on Annual Blooming and Alternate Blooming Grimes Spurs

Variety	Number of Spurs	Blooming Record		Average Length Area per spur in square inches (1917)	Average Length of 1916 Growth (cm)	Average Length of 1917 growth (cm)	Average Length of 1918 growth (cm)	Total Average Length of spur (cm)	Number Leaves per Spur 1917	Average Age of Spurs in Years
		1917	1918							
Grimes	100	*B	B	14.21	.624	3.402	0.992	7.786	8.39	5.99
Grimes	84	B	O	13.85	.621	2.592	0.919	6.574	6.94	5.51

*B—Spurs blossomed; O—Spurs did not blossom.

It can be seen that those spurs which bloomed in succession when compared to the alternate blooming spurs, had more leaves and a greater leaf area in 1917, a greater yearly growth in 1916, 1917, and 1918, and had a greater total length of spur. The two groups of spurs were approximately the same age.

Fifty-four Rome Beauty spurs which bloomed in both the years 1917 and 1918 compared to 52 spurs which bloomed alternately in these years showed practically these same results.

Although these same correlations may not hold with the other varieties when the work is compiled, still these results indicate that the spurs which bloomed in succession were the more vigorous and suggests that good growth and vigor up to a certain point, not only are not opposed to, but rather encourage, fruitfulness.

It was noticed that the Grimes tree had made a better general growth throughout the whole tree in 1917 than it had in 1914-15-16, or than it did in the year 1918. All spurs made a longer average growth in 1917 than in any preceding year. Following this growth, we got many spurs blooming in 1918 that had bloomed in 1917. When the growth over the whole tree slowed down in 1918, and the spurs made a shorter yearly growth, a much smaller percentage of the spurs bloomed in 1919 that had bloomed in 1918 than the percentage of spurs which had bloomed successively in 1917 and 1918. This indicates again that vigorous spurs are more liable to bloom successively, eliminating of course the factor of fruit setting.

General observation shows that spurs which make very little yearly growth, bloom very little, likewise the proper balance causing fruitfulness seems to be upset, when spurs are forced out into excessive wood growth and their fruiting power is lessened. *Heinecke's work showed a greater set on vigorous spurs and Yeager found that the fruit on the more vigorous spurs was larger. Both of these results were verified in these investigations in a general way. Our work suggests that those orchards which are well cared for, which includes the best cultural, fertilizer, pruning and spraying practices, and which as a result produce spurs, which have a large leaf area and a good yearly growth, will bloom more regularly, other things being equal, than the orchards, which due to a lack of care produce spurs, which make little yearly growth and have small leaf areas.

From the results in Table IX we might also assume that those spurs which bloom successively would have a greater carbohydrate content, if chemically analyzed, than similar spurs which bloomed alternately. Those spurs which bloomed successively or in 1917 and 1918 proved to have had more leaves and a greater total leaf area, as well as length growth in 1917 than the alternate bearing spurs. Samples of various spurs have been collected and preserved at different months of the year for the past two years, but unfortunately it has been impossible to have them analyzed up to this time.

SOME VARIETIES ARE BIENNIAL BEARERS—OTHERS ARE ANNUAL BEARERS

After having obtained the above data, the fact remains that certain varieties are biennial in bearing habit, while others are not. Omitting the question of lateral and terminal fruit bud formation, which is a big factor in certain varieties, this paper seems to indicate that the biennial bearers are biennial probably because, during the year that they bloom heavily, most of the spurs on the tree bloom and set fruit and thus do not bloom the next year. While in the other

*Heinecke, A. J., Cor. U. Agr. Exp. Sta. Bul. 393.
Yeager, A. F., Ore. Agr. Exp. Sta. Bul. 139.

group of trees, many of the spurs either do not bloom or if they do, many of them do not set fruit and thus are more liable to bloom the next year. If this last statement is true, which I have no proofs for and which is thus open to question, then this problem finally dips into the sterility and pollination question as well as the nutrition problem. It is probable that when the biennial bearers, set a heavy crop in the first year, the spurs on such trees make little growth during the same year. Correlating this with the above growth studies, we would expect few spurs on such trees to bloom the next year from a straight nutrition standpoint. If the annual bearers do not set as heavily, or if a smaller percentage of their total spurs set, then the chances are that such spurs would grow more during the crop year, than the spurs on the biennial bearers. In such a case, we would again expect from the above studies on spur growth that many of the spurs on the annual bearers would bloom for the next crop, especially if such spurs had not bloomed or set the previous year.

It may be possible to break up the biennial bearing of certain varieties of apples either by altering the cultural, fertilizer or pruning methods as suggested by different investigators, and after seeing what light certain pollination studies may throw on the problem, but at this time we have no definite information to offer on this point based upon investigational work of this station.

CORRELATIONS BETWEEN WEIGHT OF APPLES AND WEIGHT OF SEEDS

In this study of fruit spurs, each fruit produced was weighed the seeds removed, counted, graded as to size, whether abortive or not, and finally weighed. While these data were taken to study the influence on spur growth primarily, still it was possible to draw some correlations between size of fruit, weight, and number of seeds, and also to determine the influence of weather conditions on pollination and the number of seeds produced in fruit.

Correlation tables, between weight of apples and weight of seeds, were worked out with the different varieties in different years with results as follows:

Northern Spy	1917	54 specimens	$r = .8468$	$\pm .0664$
Ben Davis	1917	113 "	$r = .6570$	$\pm .036$
Baldwin	1917	40 "	$r = .5260$	$\pm .0767$
Grimes	1917	46 "	$r = .4590$	$\pm .0209$
Grimes	1918	98 "	$r = .5240$	$\pm .0494$
Rome Beauty	1917	87 "	$r = .3770$	$\pm .0620$
Rome Beauty	1918	72 "	$r = .5670$	$\pm .0538$

According to biometricians, if the coefficient of correlation (r) is five or six times the probable error, a correlation can be said to exist. It can be seen that in these results, r is as high as 22 times the probable error in certain cases and in all cases is above 6 times the probable error.

These data thus show a good correlation between weight of apples and weight of seed for the 5 varieties studied during 2 different years. *Weight* of seeds rather than *number* of seeds was used in this correlation, since the term number of seeds may be misleading unless one knows whether total number of seeds or total number of good seeds,

is meant. Certain varieties have a higher average number of abortive seeds than others, and this number varies within the variety in different years. The abortive seeds weigh practically nothing and thus *weight* of seeds is a clearer term to use in designating the amount of good seeds or seed value. Later data will show however that weight of seeds and number of good seeds are very closely correlated so that these correlation coefficients would vary but little if number of good seeds had been used in the correlation work rather than weight.

Although these correlation coefficients appear positive in every case studied, it does not mean that there would be no exceptions to this correlation. We can easily find individual specimens which are heavy with few and light seeds or the reverse. Again, many instances have been observed where specimens of fruit have developed perfectly with practically no seeds, where only a few specimens per tree were produced.

*Love and Leighty working with oats have shown that correlation coefficients may be influenced by seasonal variations, environmental factors, varieties, and cultural methods. Thus, it is barely possible that certain varieties of apples might not show this correlation. Within the same variety, again, the coefficient correlation might vary under different orchard management or in different years. Pollination would of course exert a decided influence on this correlation.

Where only a few specimens per tree were produced they might attain large weight and good size with very few seeds, but under orchard conditions, on trees 20 years old, bearing from 4 to 5 barrels per tree, these data indicate rather clearly that those fruits which have the greater number of good seeds, or the greatest weight of seeds, will generally be the larger specimens.

* TABLE X

Showing the Average Weight per Apple, Weight of Seeds, and Number of Good and Abortive Seeds

Variety	Number of Specimens	Year	Average Weight per Apple in grams	Average Weight of Seeds per Apple in grams	Average Total Number of Seeds per Apple	Average Number of Good Seeds per Apple	Average Number of Abortive Seeds per Apple
Baldwin	40	1917	126.500	0.2447	7.40	4.05	3.35
Baldwin		1918	128.350	0.3111	8.90	5.60	3.30
Grimes	46	1917	105.934	0.2915	7.60	4.50	3.10
Grimes	98	1918	71.144	0.360	9.70	6.90	2.80
Rome Beauty	88	1917	132.613	0.4010	8.80	5.60	3.20
Rome Beauty	72	1918	125.888	0.4574	9.29	6.69	2.60

THE INFLUENCE OF WEATHER CONDITIONS ON POLLINATION AND ON THE NUMBER OF GOOD AND ABORTIVE SEEDS IN APPLES

An influence of weather conditions as affecting pollination and as a result the number of good and abortive seeds in apples is shown in the foregoing table. The average weight of apples, weight of

*Love, H. H. and Leighty, C. E., Cornell Univ. Agr. Sta. Memoirs 3 and 4.

seeds, total number of seeds, number of good seeds, and number of abortive seeds, were obtained for all fruits in the fruit spur projects for the years 1917 and 1918 for the Baldwin, Grimes, and Rome Beauty varieties.

A study of the results shows that in all of these varieties, there were from $1\frac{1}{2}$ to 2 more seeds per apple in 1917 than in 1918, and that of the total number there was a higher percentage of good seeds and a correspondingly lower percentage of abortive seeds in 1917 than in 1918.

A study of the weather conditions for these years shows that in 1917 the weather was cold and not very clear at blossoming time with the result that the bloom was held back. Finally when the buds did open, the blooms lasted only a short time and the pistils soon became unreceptive. On the contrary, in 1918, the weather was warm, mild, and sunny during blossoming time, the pistils remaining receptive for a longer period, there was more light, and the bees could work more thoroughly, and over a longer period. Thus the weather, including temperature, light, wind, etc., at blossoming time exerts a marked influence through its effect on lengthening the blooming period and bee activity on the number of good seeds on the average that apples will have during any one season.

THE INFLUENCE OF SIZE OF CROP ON SIZE OF INDIVIDUAL SPECIMENS AS CONTRASTED TO THE INFLUENCE OF NUMBER OF SEEDS ON THE SIZE OF INDIVIDUAL SPECIMENS

We could naturally assume from the preceding correlation coefficients that if the crops were of about the same size on a tree each year, and if the other cultural practices affecting vigor of spurs were constant, then the individual specimens on a tree should be larger in the year that was favorable for good pollination. If, however, the tree had a much greater crop during the good pollination year, then the average size of the fruit would not probably be increased.

This is exactly what happened in the case of the Grimes and Rome Beauty (Table X). With more good seeds and more total seeds in 1918, the average size of apples should have been larger than in 1917. However, it was smaller. Records show that these two trees produced over twice as much fruit per tree in 1918. Thus, although there were good correlations between the weight of seeds and weight of apples for each individual year, still, even with more and heavier seeds in 1918, the individual specimens were smaller than in 1917 due to the much greater number per tree in 1918. The Baldwin variety, which bore only a very light crop in both of the years, had larger fruit in 1918 than 1917, since the amount of fruit was insufficient to affect the average size in either year.

SUMMARY

1. Apple thinning experiments, carried on from 1912 to 1919 inclusive, show that neither the tree as a whole nor the individual fruit spurs are influenced by the removal of part of the crop so that the tree or spurs bloom again the following season. Fruit thinning, then, does not affect the annual bearing of apple trees.

2. The size of the individual specimens left on the tree after thinning is greatly increased during the same year as a result of the removal by thinning of part of the crop. More marketable fruit is produced by the thinned trees and increased size of each apple in cases where the trees are bearing a good crop of fruit. This influence on size is lessened or lost altogether when trees are bearing light crops.

3. The spurs on certain varieties of apples *bloom* more regularly than those of other varieties, but this does not mean that such spurs and varieties *bear* more regularly. A more likely explanation, with reference to fruit spurs only, of why certain varieties are annual bearers, is given in numbers 7 and 8.

4. Spurs which set fruit one year, generally do not blossom the next year.

5. Spurs which blossom one year but do not set fruit, often blossom the next year; others do not, however.

6. These results indicate for the varieties studied that the spurs, which blossom two years in succession make a greater yearly growth, have more leaves and a greater total leaf area in the year preceding the second successive blooming year. Such spurs have a greater total length and thus all indications show that they are more vigorous. Thus growth and vigor to a certain degree do not oppose, but rather encourage, fruitfulness.

7. These results indicate that a variety is not an annual bearer because the same spurs bear in succession. They indicate that either a certain percentage of the total spurs on such varieties do not bloom in the heavy crop year and thus such spurs bloom and set fruit the next year, or if all the spurs do bloom, a certain percentage of the spurs do not set and thus more readily bloom and set the next year.

8. These results suggest that probably a large proportion of the spurs on the biennial bearers not only bloom, but also set fruit in the crop year. Such spurs then do not readily bloom the next year. Observation shows that trees bearing heavy crops make very little spur growth during such years. We would expect then from number 6 that very few spurs on such trees would bloom the following year. If greater spur growth was secured on the annual bearing varieties, then a greater proportion of spurs would bloom in the off-year, especially the non-blooming spurs of the year before.

9. Certain varieties which produce fruit yearly, form fruit buds terminally and laterally on one year old growths to such an extent that the production of fruit from these sources is often enough to class a variety as an annual bearer without reference to its fruit spurs. It is also possible that some varieties produce a higher percentage of fruit spurs yearly than do others, and as these gradually form fruit buds, some annual fruit may be produced. However, there are many so-called annual bearers that do not produce fruit by any of these methods and a more reasonable explanation of their annual bearing is given in Nos. 7 and 8.

10. If the statements under Number 7 and 8 finally prove to be justified in later work, then the whole problem of biennial and

annual bearing appears to be affected to a degree by the sterility and pollination problem and is not one of growth and nutrition only.

11. It may be possible to break up the biennial bearing of certain varieties of apples either by altering certain cultural, fertilizer, or pruning methods as suggested by different investigators, and after seeing what light certain pollination studies may throw on the problem, but at this time, we have no definite information to offer on this point, based upon investigational work of this Station.

12. There appears to be a good correlation between the weight of the individual apples produced on a tree and the weight of seeds in each fruit. Since the number of good seeds and weight of seeds are correlated, this correlation would probably hold between weight of fruit and number of good seeds.

13. Weather, including temperature, wind, sunshine, etc., exerts a marked influence, through its effect on the length of the blooming period, light and bee activity, on the number of good seeds and the weight of seeds in individual apples on a tree. More good seeds and a greater weight are produced in warm sunny seasons when the pistils are more receptive, and the bees can work longer and more effectively.

14. With the same crops per tree and the same cultural practices, thus keeping good vigorous spurs, the size of the individual apples of a tree should be larger in those seasons which have good weather at pollination time.

15. If the crops per tree are much larger in certain seasons than others, then the fruit will not be larger, even though there are more good seeds and a greater weight of seeds. The correlation between weight of seeds and weight of individual apples will hold true, however, in each of the separate years.

Observations on Characters of Forms of Malus

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AS FIRST generation seedlings of apple crosses begin production of flowers and fruit, comparisons must be made between individuals of each group and between these seedlings and the two parents. These comparisons deal with the specific and varietal characters exhibited by the various individuals and involve matters of form, color, size, numbers, texture, flavor, hardness, season, vigor, and so on to the end of the list of tangible things that may serve to indicate resemblances and differences.

In pursuing such comparisons questions arise at every step in regard to the constancy and relative value of the various parental characteristics that are combined in the seedlings between which comparisons are attempted. In comparing characters of seedlings with like characters of parents it is essential that there be in mind a somewhat definite understanding as to what may be regarded as the

type of each particular character as it appears in the parent. How shall type be understood for those characters which vary within wide limits in such matters as form, color, size and numbers?

In the characterization of the genus *Malus* we read, "petals 5, rounded, clawed." Casual examination of flowers of almost any standard variety will lead to the acceptance of this characterization without question; but examine more carefully, count the petals in one, two or more hundreds of flowers and it is likely to appear that, while the majority have five petals, there are varying numbers of flowers that depart from this number and have from four to eight or even more, and, further, some petals are twice as wide as others, with claw twice as long. A seedling of a parent exhibiting this variability in number and form of petals has a considerable number of flowers showing variations in the same direction, some flowers with as many as 10 petals, which vary widely in form and length of claw. The question is presented, was the variation noted in the parent a mere fluctuation, a temporary departure from normal, or had this parent developed a tendency towards variation in this manner and was this tendency transmitted and intensified in the offspring? This suggests still another question; could this seedling be bred in line of this petal variation and a form developed comparable with a form of *Malus spectabilis* which regularly has petals in numbers from 12 to 29? I believe this possible, and the chief value in such procedure would lie in evidence gained that what, when first observed, might easily have been accepted as an unstable fluctuation was, in reality, heritable.

Most characters of the apple, whether of tree, leaf, flower, or fruit are variable, some of them extremely so, as for example, length of petiole, length of pedicle, size of leaf and number of stamens; certain other characters are reasonably constant, as for example, number of calyx lobes. While cases have been encountered in which the calyx lobes were one less than the normal of five, and other cases having one above the normal, they are rare.

The number of carpels in the apple ovary is said to be 2 to 5, mostly 5. Of 32 named varieties, fruits of only four were found constant in having 5 carpels; fruits of the other 28 varieties varied as to number of carpels, some rarely, others more commonly; the most variable was Winter Rambo, for in this variety 23.14 per cent of 1050 fruits had numbers of carpels, mostly above, but in 1 case below the normal of 5. Of 28 crab forms, fruits of only 2, Soulard and Hyslop, held constantly to 5 carpels. In fruits of *Malus flore pleno* 19 per cent had 5 carpels and 81 per cent had more than 5; of fruits of *Malus spectabilis* examined, 13 per cent had 5 carpels and 87 per cent had more than 5; at the other extreme, fruits of *Malus Arnoldiana* had 99 per cent, and fruits of *Malus atrosanguinea* 96 per cent with numbers of carpels less than 5. More than 6,000 fruits were examined from the 23 crab varieties showing departures from the normal number of carpels and more than one-third (33.95 per cent) had numbers of carpels other than 5. The maximum of carpels was attained by *Malus spectabilis* in which 8 fruits had 8 carpels each, one had 9, one 11 and one 12; next to this was *Malus*

Malus flore pleno in which 8 fruits had 8 carpels and 3 had 9 each. In these 2 cases the additional carpels were mostly in a second whorl superposed upon the first. The minimum of 2 carpels was found in 2 fruits of *Malus Arnoldiana* and in 1 fruit of *Malus Sargentii*.

Manuals of Botany tell us that each carpel in *Malus* fruits contains two ovules. From examination of small numbers of fruits the opinion was entertained that this character was constant, but later examination of large numbers of fruits has shown that departures from the normal number are quite common. Of 21 standard varieties, fruits of only 2, Collins and Arkansas, held constant in having 2 ovules in each carpel. Departures from normal by the other 19 varieties were all in the direction of increase in numbers. In most cases the additions were small, but for Winter Rambo amounted to nearly 11 per cent and, for Shockley, to almost 85 per cent (84.63). The 19 varieties, taken as a group, showed an increase above normal, in numbers of ovules, of 8.23 per cent. Of 25 species and varieties of crabs, fruits of which were examined, 12 held with perfect regularity to the normal of 2 ovules to each carpel. In 4 of the forms were fruits in which a few ovules had been suppressed; *Malus Schiedeckeri* was short 16, a crab-like variety of *Malus* *Malus* 6, *Malus Sargentii* 4, and *Malus Ringo sublobata* 2, in all 28 ovules less than normal. Fruits of the other 9 forms contained ovules in excess of normal in numbers ranging from 1 for Yellow Siberian Crab, to 81 for *Malus Malus flore pleno* and 300 for *Malus spectabilis*. The large excess in these 2 forms was not unexpected, for both are abnormal in most characters. Most standard varieties and, likewise, most crabs do, then, vary in numbers of ovules in the carpels, not regularly or excessively, but enough to class the character as inconstant.

A most distinctive character of species and varieties of *Malus* is the persistent or deciduous habit of the calyx lobes. With standard varieties calyx lobes are, as a rule, persistent, but in some varieties fruits having regularly deciduous lobes are occasionally found, notably among fruits of Wythe, and rarely in fruits of 2 or 3 other varieties. With the crabs some species or varieties such as *Malus floribunda*, *Malus Arnoldiana*, *Malus baccata maxima*, *Malus Ringo*, *Malus Sargentii*, *Malus Siberica*, *Malus microcarpa* and both the arborescent and dwarf forms of *Malus Toringo*, bear fruits in all of which the calyx lobes are deciduous. On the other hand *Malus Soulardi* and *Malus spectabilis* have fruits whose calyx lobes are in all cases persistent. With other crab forms there is a division; some of the fruits on any particular tree have the lobes persistent, while for other fruits they are regularly deciduous; thus for *Malus atrosanguinea* 99.16 per cent of the fruits had deciduous calyx lobes and only .84 per cent persistent lobes; in one form of *Malus prunifolia* 2.85 per cent of the fruits had deciduous lobes and 97.15 per cent retained the lobes. One red-fruited form of *Malus baccata* had 88.5 per cent of the fruits with deciduous lobes and 11.5 per cent. with persistent lobes; another variety of *baccata* had 83.43 per cent of the fruits with deciduous lobes and 16.57 per cent with persistent lobes. These last percentages were determined from 71,250 fruits, the product of five trees for three years. Behavior of

calyx lobes has been observed and recorded for 41 crab forms, mostly from sufficiently large numbers of fruits. For 16 of these forms the lobes are regularly deciduous; for 13 forms they are as regularly persistent and for 12 forms there is a division, some fruits on each tree having deciduous, others persistent lobes, the percentage varying widely. Division on a character so distinctive as this, as it appears in fruits of these 12 forms of *Malus*, is strongly suggestive of hybridity and when this division is considered in connection with observed variability in most other characters the evidence of hybridity becomes quite convincing. Evidences of hybridity, however, are not to be limited to those forms that vary in this calyx character; some of the crabs exhibiting constancy in this, are so widely variable in other characters, that their hybrid nature is as evident as in the 12 forms variable as to calyx. In fact, it is believed that instability in characters, as found in most of the crab forms in the station collection, appears as a direct result of hybridity.

Naturally there are wide differences between these crab forms in the degree of inconstancy of characters; some exhibit greater stability, and a higher degree of fixity in characters than others; in some, observed inconstancy may be limited to characters of lesser importance, in others it involves the most distinctive specific characters. The forms most constant in important characters may be supposed to have existed through an indefinite number of generations without admixture of widely different forms; they are the forms that most nearly approach wild types and they have a degree of stability that gives them the power to dominate in the progeny of such crosses as may be made with them. There is no apple form, either standard variety or crab, in the collection that has a known history beyond the seed parent; a few are known to be seedlings of other forms, but in no case is the pollen parent known and nothing whatever is known of more remote ancestors.

I might go on and detail facts regarding variations in size of flowers, numbers of stamens and styles, size and form of leaves and fruits, for in all these characters there is as frequent and as wide variation as for those characters that have been considered, but the general statement that all characters which may serve to separate and distinguish species and varieties, are variable, often extremely so, will be sufficient.

How these inconstant apple characters will transmit, how strongly they will impress themselves upon hybrid progeny and how they will segregate in a second generation can only be determined by growing seedlings of controlled crosses to full development and then, from these seedlings, producing a second generation from self-fertilized seeds. This is a long and tiresome process; it involves much uncertainty and deserves to be regarded as one of the most discouraging features of apple breeding. Something, however, is to be learned from study of first generation seedlings from controlled crosses and this study can be made, at least in part, in connection with the descriptive work which is assumed to be essential to the maintenance of complete historical records of each and every seedling produced from controlled crosses, because such records will be indispensable to

proper interpretation of results from a succeeding self generation, when and if such generation is attained.

Not all groups of first generation seedlings suggest the parent varieties by their vegetative characters; seedlings of the cross Fameuse X Ben Davis exhibit no character of growth habit, bark color, or leaf size that is perfectly characteristic of one parent and not of the other. Such seedlings must, of course, be described, but judgment as to their affinities should be deferred until flowers and fruits are available. Seedlings from matings of varieties with large leaves such as Oldenburg and Yellow Transparent, and with varieties such as Jonathan and Ben Davis which have small leaves, show, in the majority of individuals, leaves of large size, but individuals with small leaves and others having leaves of intermediate character are not wholly wanting. There are other groups of seedlings that exhibit in many characters, and sometimes in all, unmistakable dominance of one or the other of the parents; these are, in most cases, the product of crosses in which a large-fruited variety is mated with a small-fruited crab. Seedlings of crosses involving *Malus floribunda*, *Malus Sargentii*, *Malus Toringo*, *Malus atrosanguinea* and possibly a few other equally distinct forms, whether these forms appear on the male or female side, nearly always resemble these forms in a striking manner. Trees from the cross Tolman X Toringo are, in appearance, Toringo trees that have been invigorated and improved without sacrificing strong resemblance to the male parent; the same is true of crosses between *Malus floribunda* and Fameuse, *Malus atrosanguinea* and Tolman, and various other similar combinations.

Since hybrid seedlings now available include 495 distinct parental combinations representing 44 standard varieties and 45 forms of crabs, they are of great variety and afford ample material for such studies of character behavior as may be undertaken. It is entirely proper to class such studies as are here suggested as research, since they involve "continuous and laborious search after truth"; they constitute a major part of experimental breeding, because through them must be developed the means for determining manner and process of evolution. The field here open is promising, but the demands upon patience and energy are severe, discouragements are likely to be frequent, and only tenacity of purpose will lead to attainment of such degree of success as may be accepted as a satisfactory reward.

Preliminary to, in fact prerequisite of, such studies as I have in mind, is an intimate knowledge of generic, specific and varietal characters of the individuals of whatever group is to be the subject of study; this knowledge is only to be attained through direct observation of particular characters as expressed in many individuals; the observations must be carefully made and rightly recorded; together they constitute a body of facts upon which to base conclusions and the larger the accumulation of facts the more stable the foundation for succeeding steps.

No apology is necessary for the expenditure of unlimited effort in determining the range and direction of variation and the general behavior of any tangible characteristic of any member of a subject group.

Observations on French Horticulture

By S. W. FLETCHER, *Pennsylvania State College, State College, Pa.*

I MUST admit that my observations on French Horticulture are fragmentary and perhaps distorted. They were made after 4 years of war had left their impress, in abandoned vineyards, unpruned fruit trees and neglected gardens. The horticulture of France suffered far more during those tragic years than her agriculture. Nevertheless what I saw confirmed my admiration for the horticultural genius of the French.

My most vivid impression was the small size of the holdings. Compared with our farms, those of France seem pigmy. There are some large farms, equal to our best in every respect, but most of them are under 10 acres. The average size of all the farms of France is 15 acres; of the United States, 145 acres. Moreover, the 15 acres usually are in a number of widely scattered parcels. I met a Burgundy grower who owns a farm of 10 acres, divided into 43 fields, some of which are 2 miles apart. In leasing 250 acres for the use of the American Expeditionary Forces Farm School at Allerey over 100 land owners were involved. These are not exaggerated illustrations.

The small holdings and scattered fields explain much that seems backward in French agriculture. They account for the lack of machinery, and for the large amount of hand labor with primitive implements. With the aid of modern machinery, one energetic American farmer accomplishes as much as 10 French peasants. It is interesting to observe that in reorganizing the reclaimed portions of the devastated area the French government is assigning each man a holding of one field; and is replacing the French farm village with the American farmstead—a home on the farm, instead of in the village. These are the main reasons why France has fruit gardens instead of orchards. There are a few large plantings of fruit, particularly of the olive and the grape, but for the most part they are under 10 acres. The largest apple orchard I saw in Normandy was less than 20 acres. France is a land of garden farming.

Another distinctive feature of French horticulture is the training of dwarf trees. To a French gardener, a fruit tree is plastic material, to be moulded into any form that may please his fancy. They delight in the formal style both in fruit growing and in landscape gardening. An American fruit grower cannot be expected to become enthusiastic over an apple tree in the form of an umbrella, or a pear tree in the shape of a rooster, except as a demonstration of the skill and patience of the gardener. Practically all of the dessert fruit is growing on dwarf trees. Most of the trees are grown "en espalier," trained to walls or wires, and in numerous geometric designs. Peaches growing in a cold frame are of interest to an American. A Frenchman spends about as much time on a dwarf tree, bearing 30 fruits, as an American on a standard tree bearing 3,000 fruits.

Dwarf trees are grown commercially as well as for home use. Near Lyon I saw several plantings of at least 10 acres each, all the trees being trained to wires, like grapes. The French grow dwarf trees commercially even when much larger yields could be secured from standard trees. The Superintendent of the School of Horticulture at Beaune estimated that one man could care for one acre of dwarf trees, from which a gross annual return of about \$800.00 might be expected. The head gardener of the Horticultural Society of Le Mans stated that an average crop per tree was twenty-five fruits or twelve kilos. He considered 1500 kilos, or 3,000 fruits a fair crop from his acre of land in dwarf trees. I hazard the opinion that the French are not producing as much fruit per acre as they should, because of their passion for geometric training. Dwarf trees produce fruits of remarkable beauty and quality, but few of them. That is why one pays 15 to 30 cents each for apples in Paris.

In comparison with these petted and pampered dwarfs, the standard trees are sadly neglected. Practically all are in sod and full of brush, and many are garnished with mistletoe. Perhaps this is another case of "C'est la guerre", but I am under the impression that even before the war the standard trees received little of the care that is lavished on the dwarfs. Nowhere did I see an apple or pear orchard that would satisfy the best American ideals. Possibly this is because such a large proportion of the fruit from standard trees is used only for making cider. One does not live in France very long before observing that fruit is grown mainly to drink, not to eat, as was the case in America scarcely 75 years ago. The trees are often kept 5 or 6 years in the nursery before transplanting, and are headed very high. I have a photograph of a nursery row of apple trees, none of which have branches less than eight feet from the ground.

The most striking deficiency in French orchard practice is in spraying. It seems strange that a land that gave birth to modern spraying, at Bordeaux, should not have applied it more generally. The vine is sprayed and dusted quite thoroughly and the French have an excellent line of vineyard sprayers; but one looks in vain for an orchard power sprayer, or even for a good hand pump. At the great industrial and agricultural fair of Lyon the only spray outfit for fruit trees that I could find was a 5 gallon knapsack pump. A winter wash of whale oil soap is often given, but summer sprays of sulphur or tobacco, are rare. I met no one who uses arsenites, although the loss from chewing insects, especially a species of green fruit worm, is often heavy. The apple suffers seriously from woolly aphis. The fruits on dwarf trees are commonly covered with paper sacks soon after setting. This gives them a waxy finish and delicate coloring. The Chasselas and other table grapes are also bagged.

Of varieties there is no end, and most of them are local. The pears in French gardens are our old friends, the Comice, Clairgeau, Angouleme, Louise, and even the Bartlett, which is here the centuries old "Bon Chretien." Many of the plums and cherries are familiar, but the varieties of apples are wholly new. There are some remarkable late blooming apples in the orchards of Normandy. On May 20

I saw trees that were barely bursting their winter buds, although the petals had fallen from most of the other trees. There is excellent material here for the breeding of late-blooming varieties for America. At several points in France, and near Coblenz, Germany, I observed successful roadside planting of apple trees. They were mostly cider apples and were not sprayed. The trees are owned and the fruit harvested by the village or commune. In southern France the Persian walnut is grown as a roadside tree. I was told that the income from the nut harvest contributed very materially to the upkeep of the roadbed. In America, roadside fruit trees would need to be sprayed frequently or they would be pest breeders; and I fear the public, not the township, would get most of the fruit. Roadside planting of fruits and nuts seems to me wholly impracticable here, except, possibly, under private ownership.

The premier fruit of France is the vine; it exceeds in importance all other fruits together. I have heard it estimated that 15 per cent of the labor of France is engaged in the growing, making and selling of wine. A Frenchman drinks water only from dire necessity. I read some of the literature of the National Society for Prohibition and looked in at a sparsely attended meeting. Possibly this seed may bear fruit some time, but the plant will have an exceedingly slow growth in this very unresponsive soil.

I was interested in the hail guns which are scattered through some of the best Burgundy vineyards, about half a mile apart. These are funnel shaped, and about 20 feet high. On the approach of a hail cloud a telephone warning is sent to all the stations in the district and an immense rocket is discharged into the cloud by the gunner. These burst at an altitude of 2000 to 3000 feet and, so I was told, dissipate the cloud. I do not question the efficiency of this treatment on a French hail storm, but I am skeptical whether an American hail cloud could be swerved an inch with sky rockets. Smudging for frost protection has been abandoned as impracticable.

Interesting as are the vineyards of France, the vineyards of the Rhine and the Moselle rivers, in Germany, impressed me as the last word in spectacular and laborious horticulture. Slopes at an angle of 45 degrees, or greater, are terraced and planted. Pockets are cut from the face of cliffs and filled with soil brought from the lower slopes on the broad backs of German men and women. The gardeners cover the surface of this made soil several inches deep with fragments of rock, to prevent erosion, absorb heat and conserve moisture. The labor of many generations has been expended in terracing these mountains. The wine from the Rhine vineyards is worth several times more than that made from the same variety when grown on heavier soils, or on more level land.

I spent a day in one of the oldest, if not the oldest, commercial strawberry growing districts in the world, near Brest. It was here that a Frenchman, Captain Frezier, brought plants of *Fragaria chiloensis* from Chili in 1712, having saved them from death during the long voyage by sharing with them his scanty allowance of water. They became the progenitors of a notable strawberry industry, which persists to this day. The plants are grown in raised beds,

about three feet wide, and are spaced uniformly. Runners are kept pulled off until the third year, when a new bed is started and the old one plowed under. Most of the berries are picked hulls off, as was the practice in America 75 years ago. They are packed in returnable sea-reed or willow baskets holding 5 to 25 pounds, and brought 18 cents a pound wholesale this year.

The nursery industry of France was practically ruined by the war. I visited Angers, once the center of a large trade with America, and found great desolation. The nurserymen are very bitter about the American restrictions on importations. It will take several years for the industry to recover; by then I hope America will have developed its own resources to the point where it no longer will be dependent on Europe for fruit stocks and ornamentals. French nurserymen will not have in the future so great an advantage in the way of an unlimited supply of cheap, skilled labor.

Much has been said in some of our periodicals about the destruction of orchards in northern France, and the impression has been left that this will result in a greatly increased demand for American fruit abroad. It is true that thousands of acres of orchards have been ruthlessly, and in most cases needlessly, destroyed by the Boche, but I doubt if the loss is great enough to have much influence on the demand for American fruit. The American Red Cross has contributed 40,000 fruit trees to help replant the devastated area. Lest we forget, let me remind you that 6,000 square miles, containing 15 per cent of the tillable land of France, was wholly or partially destroyed for agriculture. This is an area equal in size to the states of Connecticut and Rhode Island. About 250,000 acres are beyond redemption for agriculture.

The emphasis on handicraft in the horticulture of France is reflected in the type of instruction offered in the schools of horticulture. At the National School of Horticulture, at Versailles, the students have 3 hours of lectures and 6 of practice each day. The 3 year course leads to a diploma. The school has 25 acres of land, crossed with numerous division walls on which fruit trees are trained. The dwarf trees are closely planted, and vegetables are grown between them. There are 1,400 varieties of fruits in this 25 acre garden. The students learn by practicing under the watchful eye of the gardener. It is a trade school, not a college. College education in horticulture, as we know it in America, does not exist in France. The National Horticultural Society is active in horticultural extension; it sends out experienced men to give lectures and demonstrations in public gardens and parks. Nearly every city has a local horticultural society. The one at Le Mans, for example, has a membership of 600; the men pay 10 francs a year, the women 5 francs, and the city contributes 1,300 francs. The society maintains a *Jardines plantes*, greenhouses and a fruit and vegetable garden. Each member is supplied with fruit, flowers and vegetables from the garden, in order as determined by lot.

I have reserved until last what is perhaps the most distinctive feature of French horticulture, and one that is most worthy of emulation in America. The French are plant lovers. Amateur horti-

culture reaches its highest expression in France. No home is so humble, no yard so small, that it is not utilized and embellished with fruits, flowers and vegetables. Every inch of space is made to count. The high stone walls that almost invariably surround the home grounds are draped with fruits; even the garden walks are edged with cordons. There are coldframes against the sunny walls, and vegetables on every foot of land not otherwise occupied. Everybody is interested in horticulture; it is the national diversion of a thrifty and artistic people. With this background of amateur interest it is easy to see why the French have contributed more to horticulture, especially in plant improvement, than any other race with the possible exception of the English. The problem that the American Pomological Society is now facing—how to revive amateur interest in pomology—does not exist in France. It is most unfortunate that great achievements in commercial horticulture have been wrought at the expense of the amateur interest that our forefathers brought from Europe. In old days, when nations went to war, the victors brought home plunder. The only plunder Americans brought back from overseas aside from a deeper love of country, is an appreciation and appropriation of the best things in the life of Europe. One of these, I hope, is the amateur interest in horticulture.

Methods of Approach to Horticultural Problems

By HENRY D. HOOKER, JR., *University of Missouri, Columbia, Mo.*

A STRIKING feature of horticultural literature is the diversity of opinions held by our leading horticulturists concerning many fundamental questions of orchard management, and the large body of data which can be adduced to substantiate diametrically opposed views. It is my intention to point out the reason for these discrepancies, and to suggest a remedy.

Take for example the question of bud selection, and the value of pedigreed nursery stock. Hedrick (N. Y. Agr. Exp. Sta., Cir. No. 18, p. 16) states, "The Geneva Station has an experiment, which gives precise evidences on this question of pedigreed stock. Data showing the variations in diameter of tree, and in productiveness can be found in Bulletin 339 of this Station, and will go far to convince any one that uniformity of behavior as regards vigor and productiveness of tree and size and color of fruit cannot be perpetuated. . . . In conclusion, the burden of proof is upon those who advocate pedigreed trees." Shamel, Scott, and Pomeroy, (U. S. Dept. Agr., Bul. No. 623, pp. 143, 145) present abundant evidence of the isolation of strains of the Washington Naval orange by bud selection and they state, "Enough evidence has been secured in these investigations to warrant the statement that in all probability all the strains of the Washington Naval orange can be isolated through bud selection. The isolation of the strains described in this bulletin can be effected

either through the selection of bud wood from typical trees in established orchards, or from limb variations occurring in bearing trees in Washington or other strains." And again they state, "So far, not a single failure has been observed in transmitting the characteristics of the parent trees by means of the selected buds. The large amount of positive evidence as to the possibility of improving undesirable trees by top-working them with selected buds has resulted in the almost universal adoption of this practice by California citrus growers."

Then there is the question of winter versus summer pruning of apple trees. Vincent (Ida. Agr. Exp. Sta., Bul. No. 98, pp. 3, 28) gives data showing results under both methods of pruning covering a period of eleven years. He says, "The pruning of apple trees in winter to encourage wood growth, and in summer to induce fruitfulness are principles that have long been recognized by horticulturists. It is surprising to learn in reviewing the literature that these principles are based on very meager experimental evidence; moreover the experimental evidence from different sources in many ways is contradictory." And again, "On the basis of the total production for the first seven crops, summer pruning has produced the greater yield in all varieties. The average annual increase per tree for each variety was as follows: Jonathan 5.17 pounds; Rome Beauty 8.37 pounds; Grimes 7.22 pounds, and Wagener 40.98 pounds. The crop value per acre as determined by *both* color and yield shows an average gain in the 3 summer-pruned plats over winter pruning as follows: Jonathan \$52.33; Rome Beauty \$53.64; Wagener \$30.69." Batchelor and Goodspeed, (Utah Agr. Exp. Sta. Bul. No. 140, p. 3) in discussing the same problem express themselves as follows, "The majority of horticultural writers seem to favor the summer pruning of apple trees. The practice, and the arguments made in its favor vary widely and in some instances seem almost contradictory. On the other hand, some experimenters and practical workers have obtained negative results by summer pruning from the viewpoint of crop production and tree growth." In summarizing the experimental data collected from the study of 126 trees, they arrive at the following conclusions, "The summer pruned trees averaged less marketable fruit per tree than either the winter pruned or the unpruned trees. The winter pruned Gano trees produced less fruit than the unpruned trees. Summer pruning in the orchard has proven neither profitable nor successful in increasing crop yields. . . . Summer pruning reduces the area of fruit bearing wood, the vitality of the tree, and the productivity."

Now let us consider a third question of fundamental significance in orchard management, namely, the value of fertilizers. Hedrick (N. Y. Agr. Exp. Sta. Bul. No. 339) on the basis of fifteen years' experimenting to determine whether it is necessary to fertilize apple orchards, comes to the following conclusion: "The fertilizers have no sensible effect upon the yield of fruit in this experiment. The trees in this experiment would have been practically as well off had not one ounce of fertilizer been applied to them. One must conclude that if fertilizers have no value in this orchard they have no value

in many other orchards in New York." And in speaking of the specific value of nitrogen fertilizer he says, "There is slight evidence that trees on plats to which nitrogen is applied are making a greater annual growth of branches." Stewart (Penn. Agr. Exp. Sta. Bul. No. 100) working on the same problem arrives at diametrically opposed conclusions. His data were collected from eleven orchards including over 2000 trees. He concludes, "Nitrogen is apparently of much greater value in apple orchards than is generally supposed. Its addition has greatly increased the quantity of fruit. Many failures with potash and phosphate have doubtless been due to a deficient nitrogen supply."

These three illustrations show how widely divergent are the opinions of our most capable horticulturists on three important problems of orchard management: value of bud selection, effect and time of pruning, and application of fertilizer. It is evident that no definite conclusions in regard to these particular problems can be arrived at by the current procedures so long as different investigators can obtain such contradictory results. It is not as though these differences of opinion were not honestly arrived at, and substantiated by a large amount of careful and painstaking work.

These procedures have been tried out with great care and expenditure of labor, and the effects of these procedures have been judged by the ultimate improvement in quality and quantity of fruit produced. But between these two end points, there is a whole series of intermediate stages that have been neglected. It is as if we were to judge a book solely by the introduction and conclusion. These may give us the subject matter, but they do not tell us its value, or whether we should have arrived at the same conclusions. And just so with these experiments, the knowledge of the fundamental changes occurring within the plant is wanting, and it is only by means of this knowledge that we can judge the value of the effects procured. These fundamental changes are the alterations in the physiological and chemical equilibrium of the organism, at once the functions of the procedure used and the factors *determining* the effects observed. It is only by paying attention to the changes going on inside of the organism and by obtaining exact information of what these changes are, that uniformity of conclusions must result. Then there may be a division of opinion concerning ways and means, but there can be none concerning the facts.

These points may be best brought home by reference to a particular problem. Let us take for example the treatment of orchard trees by pruning, and the application of fertilizer. Stewart in the bulletin just referred to lays emphasis on the principle of limiting factors, and points it out as follows, "The weakest factors largely control and limit the crop and through them it can be affected. Consequently, the value of attention to any factor is essentially proportioned to its need. In general, therefore, applications of plant food will be of most value when it is the limiter. In the presence of other still weaker factors its effect may be wholly lost. The best orchard treatment probably consists in the discovery of crop-limiters, their elevation to the level of the other factors and the

maintenance of a properly balanced treatment thereafter." This recognition of the principal of limiting factors is absolutely essential, but a more accurate conception of exactly what limits the plant's activity is necessary. These limiting factors are not solely factors of the environment. They are relations between the environment and the organism. This may be easily illustrated by the behavior of trees to low temperatures at different seasons of the year. The same temperature which may be quite harmless late in the winter will kill buds in the spring after they have begun to open. Plants, such as cabbage, tomato, and lettuce react to low temperatures very differently before and after a process of hardening. This shows that the organism must be taken into consideration in a discussion of limiting factors, and it is precisely the organism which has been lost sight of in most horticultural investigations.

In medical practice the first essential is diagnosis, and this is the basis for prescription and treatment. Complete diagnosis involves chemical examination of the body fluids, and knowledge of their normal composition is a necessary prerequisite to recognition of diseased conditions. In treatment it is necessary to know the effects of the indicated remedies on the pathological conditions which have been ascertained. The data which physiology and physiological chemistry have placed at the disposal of the physician is his basis for practice, and similar data can be made available for horticultural problems.

The procedure which horticulturists should follow in attacking problems of nutrition and physiological regulation of fruit trees is directly analogous to the procedure used in medicine. The first prerequisite to any sound scientific horticultural treatment is diagnosis, and for this three things must be known: first, the normal relationships between the essential and indicative constituents of the fruit tree and the approximate limits within which variations may occur without involving a decrease in the quantity or quality of fruit, a change in the regularity of bearing or a decrease in hardiness and vitality; secondly, what constituents should be looked into and the significance of wide variations in these particular constituents, and the absolute amounts of these constituents will probably not be as indicative as the ratios between them; thirdly, the prevailing condition in any particular tree or orchard under investigation and the direction in which changes should be effected. Some convenient means must be found to obtain with surety and ease an indication of the actual conditions prevalent. After diagnosis has been made, the effects of various treatments, such as pruning, the application of fertilizer, grafting, etc., must be determined and the way in which these treatments affect the physiological condition of the tree and the relative amounts of its essential constituents. Finally, application to specific cases is possible on the basis of the diagnosis and a knowledge of the effects of various treatments and then it will be possible to obtain effective means of producing the desired results which always involve in the last analysis an increase in the quality and quantity of fruit production.

The value of exact diagnosis of the condition of the plant may be illustrated by some recent work of Kraus and Kraybill (Ore. Agr.

Exp. Sta. Bul. 149) on "Vegetation and Reproduction with special reference to the Tomato." These authors show that the fruit production of tomato plants depends upon a definite balance between the amount of nitrogen and the amount of carbohydrate present, there being relatively small amounts of nitrogen and large amounts of carbohydrate in productive plants. They find however that a lack of productivity may be caused by a too small nitrogen content as well as by a total nitrogen content large in relation to the carbohydrate. In such cases the nitrogen is apparently a limiting factor. Work of the Horticultural Department at the University of Missouri shows that a similar state of affairs holds for the productivity of apple trees. It is evident that a knowledge of this nitrogen-carbohydrate ratio is an essential prerequisite for diagnosis of the unproductive plant, because lack of productivity may be correlated with either a high or a low nitrogen content and effective treatment is impossible without an exact knowledge of which of these conditions is prevalent. But if an analysis is made and the relative amounts of these constituents have been determined, then it is possible to determine whether treatment involving an increase or decrease in the nitrogen supply will induce productivity.

It would seem feasible to develop a procedure suitable for most fruit-bearing plants which would give an exact indication of the prevailing physiological conditions. For this a chemical analysis of the fruit spurs of fruit buds with or without nodes is recommended, since these portions of the plant seem to have reflected in them the general physiological condition of the plant and since they are of particular interest to the horticulturist. Reasons for the determination of the nitrogen and carbohydrate content are apparent. This involves determinations of total nitrogen, protein, amino-acids, nitrates, reducing and non-reducing sugars, starch and total polysaccharides. Further determinations should be made of the moisture content, titratable acidity, hydrogen ion concentration, total ash, potassium, phosphorus, and in addition perhaps sulphur and calcium. These analyses should be made at intervals throughout the year so as to furnish a base line for the normal variation of each of these constituents and their interrelationships. Without doubt, correlations will become apparent so that the number of determinations may be reduced and the significance of the remainder increased. When sufficient work along these lines has been done to supply us with a fairly accurate knowledge of the normal amounts and relationships of the essential constituents throughout the year in each of our fruit producing plants it will be possible to state definitely with respect to any individual case in what direction these amounts or ratios should be changed. After this the effects of various types of pruning at different seasons of the year, the effect of combinations of these prunings, the effect of the application of fertilizer to plants in various conditions must be ascertained with special reference to the alteration produced in the chemical composition of the plant. Not until these preliminary investigations have been completed will it be possible to prescribe with certainty treatments that will be effective in producing the desired results.

On the other hand this procedure, the most important item of which is diagnosis, opens up enormous possibilities in horticultural science. Eventually it should be possible to analyze a few fruit spurs from a tree and to know immediately wherein the physiological condition of that tree is abnormal with respect to maximum productivity and to know what treatments will correct the abnormality. Formerly it has been the custom to recommend orchardists to carry out experiments on a few trees in their orchards with the hope of discovering better procedures than those used in the main part of their orchard, but results from such experiments usually cannot be obtained inside of several years and their value is seriously impaired by the necessary delay and expense.

In the interests of horticultural science, therefore, it is essential to collect data concerning the fundamental physiological condition and chemical composition of our fruit-bearing plants and to ascertain the approximate limits within which variation may occur without producing a decrease in the quality and quantity of fruit. The larger the body of available data on this subject, the greater will be the ease in detecting abnormal tendencies, and the surer and the more rapid will be the progress in devising means for their correction.

Cooperation in and Coordination of Investigational Work in Horticulture

By L. C. CORBETT, *United States Department of Agriculture,
Washington, D. C.*

THOSE wise, far-seeing framers of the laws which brought the American Agricultural Experiment Stations into existence, made it possible for each state to develop an institution to which its many local agricultural problems may be brought for analysis, study and investigation. In those in which horticulture forms an important economic factor, the science in which we are interested will come in for its proportionate representation on the staff and share of the funds.

Each state should, if this theory is followed, possess a staff of trained men who direct their time and effort to the solution of the pressing problems of the horticultural industries of that state. Many of these horticultural problems are local or regional in character. It is necessary, however, for the greatest degree of success in fruit production, to know the varieties best suited to a particular soil and environment. Then, too, soil types vary in different localities and the question of how to handle the soil and to feed the plant in a particular section varies so much that each farm presents problems which must be solved either by the owner, the county agent or the state horticulturist.

Not all these problems are new or fundamental in character; many in fact are local adaptations of fairly well known principles or

facts. Such work, in my judgment, must in general be done by the county agent. It is the tailoring job of the trained horticulturist. It involves fitting the practices to the crop and the conditions; it involves taking the measurement of a situation by a series of well planned trial plots to determine the size of the pattern to be used. The character of the garment and the fabric to be used may have been worked out by a Hedrick or by a Stewart, but the local tailor must insure the fit.

Beside these innumerable local and ever present farm problems which are of first magnitude to the immediate owner and operator, there are the broad fundamental problems of plant feeding and the maintenance of profitable crop returns. These problems have long been recognized, and a few institutions have inaugurated well planned long-time tests to throw light upon them, but in the main, this has been work based on the experience of a single group of investigators, namely, chemists, and not the result of the joint effort of expert horticulturists collaborating with plant physiologists and biochemists. This is probably as large a group as can at present be assembled to undertake a study of plant reactions under varying environmental conditions and upon different soil types. As soon as such men exist, however, I would add another type of investigator to this group. This individual should be as thoroughly informed regarding the relation of the soil flora and fauna to the underground parts of the plant as are our pathologists and entomologists concerning the flora and fauna of the parasites that attack the above-ground parts of plants. We would then require cooperative or group leadership in the planning, execution and interpretation of investigations designed to determine the relation of plants to environment.

It will at once be evident that an investigation so planned and executed in a single place, on a given soil type, and in a definite climatic area, would still lack the comprehensiveness necessary to make it of optimum value and importance. It should, therefore, be repeated in as many sections as the variation in soil and other environmental factors would indicate necessary to a comprehensive study of the inter-relations of plants with soils, so-called plant foods, climatic, and when possible, bionomic factors of their environment.

Such an investigation would not only involve cooperative or collective outline, planning and execution and interpretation and a coordination of effort on the part of all concerned, but also a coordination of location with industry or possible industry.

Some day I trust the forces of our research institutions may become sufficiently stabilized to permit and warrant the undertaking of comprehensive studies of such a nature. At the present time, no such investigations are under way, but work is developing which may ultimately build up a cooperating group for handling some of the broad problems of plant nutrition and plant adaptation.

What are we horticulturists really doing to solve the many problems of the industries we represent which overlap state boundaries, problems which are regional in scope? But, you will say, how about the United States Department of Agriculture handling the regional problems? Very good. It is this class of problems to

which the Department worker directs his major effort, but many of these problems are so complex in character and require to be carried out under such a diversity of environments that they immediately develop aspects which require that they be taken up within the limits of the state. Then the question of cooperation or professional privilege develops.

This question of cooperation between officers in different states and between state and Federal officers is one which should be given thought and due consideration. If the comprehensive problems of horticulture are to be investigated, the work must be carried on, as I have already suggested, by a group of investigators who will cooperate in the development of the project itself, who will act in unison in its projection, but who must have the moral, and often the active support of the investigators in the local field. There are series of investigations annually carried on by investigators that are not accomplishing their greatest usefulness.

These studies have to do with the test of sorts, the application of fertilizers, dates and methods of planting, cultivation, etc. When this great mass of work is all done, it has only very limited local significance—why? Because no two follow the same plan and as a result the work is of little value because it is not comparable and so cannot serve as the basis for broad generalizations.

The investigational work of the country has been under way for a sufficient time to warrant the industries in expecting such results. but the work as it has been and is now being conducted does not for the most part contribute to such an end.

This regrettable result is, I believe, largely attributed to our democratic system of handling the work. Each state is an independent unit and each worker is largely pursuing work along lines which he considers of importance to his constituents, or which, too often, appeal to him personally, regardless of its relation to local industries.

I trust the time will comewhen the time, effort and money devoted to variety trials, fertilizer tests, rates of seeding, etc., may all be carried out in such a way as to make the results comparable. If so simple a plan as that of all using the same outline blank for making observations on varieties were to be carried out, much progress would be made. Until we prove ourselves capable of doing so simple a thing as this, I do not hope for the successful carrying out of comprehensive, cooperative investigations involving joint work by a group of scientists representing various aspects of a problem.

The time has long since passed when centralized direction of our investigational work such as obtains in Canada was possible, except at Federal field stations. The only hope of securing records which will make possible the comparison of results obtained over a wide range of territory for any given subject is through the medium of cooperation. The physical equipment is largely provided for such work, but the desire which impels action seems in the main to be lacking. Whether this is due to selfishness or to a lack of appreciation of the value of regional work, I do not know, but difficulties are encountered in attempting to carry out regional work because state authorities fail or refuse to comprehend the importance of

carrying on work in several areas within the region under the same direction and according to the same outline for a series of years.

Unless such work is encouraged on the part of the Federal Government, there is little prospect that it will be done at all. The Federal Department should confine its work to interstate and regional problems; that goes without argument. But in order that it may do its work on such a basis, the states must recognize the function of the Federal department and facilitate the work.

I am glad to say that in general, there is no difficulty in carrying on such work; most states welcome it, realizing that even though the work is planned and executed strictly as a regional problem, every state in which it is conducted is a beneficiary, for results of local interest always develop.

I have a selfish interest in the investigational work in horticulture through the United States. I feel that the problems are so numerous and so important that with all the men and the money that can be marshalled to the attack, the result, if the utmost were done to avoid waste and duplication and to encourage cooperation and coordination of effort, would be entirely inadequate to the real needs of the industry which we are striving to serve.

In the Federal Department, we should have a clearing house for cooperative effort between the states. This must be voluntary—it cannot be compelled. Large cooperative projects cannot as a rule be inaugurated without a careful survey of the field, an allocation of responsibility, and joint financing which, so far as the Department is concerned, means going to Congress for funds. Many requests are made upon the Department for the inauguration of work on its own account or in cooperation in which it is obliged to decline to take part because its funds are specifically appropriated for a particular project which has been outlined and approved by the Congress.

These broader aspects of research which involve the cooperation of groups of scientists in their prosecution as well as a diversity of localities for their fruition, can now only be successfully undertaken by the Federal authorities at Federal field stations or upon areas within the states where suitable facilities can be provided. The states can be of great assistance to such work by encouraging those features of it which fall within their dominion and by lending encouragement to the Federal appropriations for such undertakings.

While theoretically these comprehensive studies should be carried on as cooperative activities, I do not believe the states will ever provide the stable organization and finances to carry out such work. Why should we not therefore say among ourselves, here are lines of work of such a character as to make it imperative that the state authorities carry them on independently; here is another class of problems which lend themselves to cooperative and coordinated effort among the states, work which all do but not in comparable fashion; and here is another class of problems which require group action over a wide range of conditions. Let us urge the Congress of the United States to encourage and adequately finance such activities in the Federal Department.

This is my idea of cooperation and coordination of effort in the field of horticultural investigation. "The job is big, so dig, ye terriers, dig."

Relation of Our Society to the Development of Horticulture

By J. W. CROW, *Agricultural College, Guelph, Canada*

IT IS quite in order at any time for us to consider the relation of our society to the development of horticulture in our respective countries. It will be obvious from the character of our present program that horticultural science is making progress. The subjects chosen indicate a much closer approach to the fundamentals of the sciences with which horticulture is especially concerned. Any attempt to discuss the question involves the definition of horticulture and perhaps the best thing we could do at this time would be to attempt such definition and to correct, if necessary, any erroneous ideas we may be found to entertain.

Horticulture is primarily the art of intensive plant culture, which fact may contain for us important implications if we will but follow them through to a conclusion. The best definition of horticulture, it seems to me, is that adopted by the British Royal Horticultural Society, which reads as follows: "Horticulture is a definite craft of itself and is not a department of agriculture. As differentiated from agriculture, horticulture includes the more intensive cultivation, as usually practised in gardens, of fruits, vegetables, flowers and ornamental trees." In the light of this definition horticulture takes its place by the side of agriculture as a subject coordinate with agriculture but as distinct as forestry. The key-note of the definition is in the words "more intensive" and to my mind this characterization constitutes adequate justification for postulating a separate identity for horticulture.

I am quite aware that up to the present our administrative and academic organizations have considered horticulture as a branch of agriculture, but is it not the fact that in actual practice the craft we represent is carried on as a specialty, usually more or less distinct from agriculture, as such? It seems to me the development of horticulture in the United States and Canada is hampered by the failure to realize the existence in horticultural practice of this distinction, and by our almost total failure to recognize in our administrative and teaching organizations this fundamental difference.

In our countries at the present time there is taking place a very marked development of horticulture, particularly in those lines which are less commercialized and which rest upon the enthusiasm of the amateur. You will permit me, I am sure, to insist on the importance of these new developments and to say that horticultural science could make no greater mistake than to underestimate the importance of horticulture at large to the amateur and his special interests. The art of horticulture the world over, in its highly organized commercial phases and in its equally important non-commercialized aspects, rests ultimately upon *the skill of the trained plantsman*. In all crafts and industries the keystone of the structure is the skilled

worker. Formerly, and up to very recent years, our trained gardeners came principally from Europe, but it would appear that from this time on we shall not be able to draw to any extent upon men trained overseas but that we shall be required to undertake the practical training of our own men. It is probable that out of the present situation there will evolve a new type of horticultural institution and it is with the idea of bringing this thought prominently before your minds that I venture to speak in this way at this time.

It is obvious that the best place for developing trained plantmen is where a wide variety of plants can be had for handling and study. Botanic gardens suggest themselves naturally in this connection. I do not know whether any of our existing botanic gardens are in a position to develop the sort of training I have in mind and for which they are so admirably equipped. I do know that if such a course of training were available, based on the European apprentice system, supplemented by lectures and reading, I should be among the first to make application for admission. I believe that such a course could be provided and that by a proper balance of practical work, lectures and reading, it should be possible to get as much in 2 years as would require 4 or 5 years by the European plan. With this practical training as a nucleus there would come about by natural processes of growth a grouping of advanced teaching, experimental and research activities. The beginning of this new development is already discernable and in my opinion expansion along the lines suggested is necessary to the full development of our national horticulture.

If the viewpoint herein developed is of any value in helping us to decide what kind of teaching institution is needed, it should also be of value in focussing our attention upon the scientific aspects of horticulture. Experimental and research projects in horticulture are subject to a very high rate of mortality, which is very often due to neglect of the simple elements of plant culture. We all recognize that plants must be handled in the proper way if we are to get a scientific result of value. On the other hand, it is also true that if our work is to have any value for plant growers we must aim at the fundamental problems of plant culture. The greatest service we could possibly render to horticulture would be to help the plant grower to comprehend the nature of the living plant and its reaction to the external environment. It is probable that recent work done with citrus fruits and potatoes points to a line of scientific inquiry of the greatest importance. There is some evidence to indicate that ecological factors are involved in the changes of structure and habit which occur with these plants and if this should turn out to be the case we shall have to conclude that we do not yet fully understand the relation of the plant to its surroundings. When we have reached a better understanding of this subject it seems to me we shall also have simplified exceedingly the teaching of horticulture. I venture to think that plants exhibit in their structure definite modifications by means of which they are more or less perfectly adapted to equally definite environmental conditions. If such is the case, then it

would seem possible to teach plant culture on an entirely new basis of growth, form, structure and habit.

I sincerely trust that the keenest scientific minds among us may be attracted to the study of some of these problems which appear so fundamental. It is to this end that I preach a horticultural class-consciousness which recognizes a special need and which would devise special machinery in order to meet the requirements of the case.

Coordination in Teaching Horticulture

By W. L. HOWARD, *University Farm, Davis, California*

COORDINATION in its final analysis is cooperation and co-operation is a mighty power for getting things done. I suppose every college or university that offers systematic instruction to resident students would claim that its courses are carefully coordinated. And perhaps they are in the sense that completion of one course fits the student for pursuing another. No doubt this sort of coordination is quite successful in such subjects as mathematics, physics, astronomy and other exact sciences. But what of agriculture? The writer looks upon agriculture as an aggregation of sciences that are united into various combinations to support and interpret the technical subjects, and point the way to successful farming practices. It is assumed that the purpose of agriculture is the production of food, raiment and shelter. In this discussion it is understood that applied farming may range all the way from the work of the botanist and chemist to the actual tiller of the soil. Even the engineer, if he is willing to be born again, may become a sort of glorified farmer.

After this rambling preface I may say that I believe practically all of the agricultural colleges of the country, especially where they are connected with universities, lay out their four year courses on the theory that certain subjects, both fundamental and technical, are necessary, and if properly mastered will produce a finished product that is sent out labelled as a potentially successful farmer.

Some colleges are becoming very liberal in offering groups of subjects which permit the student a rather wide range of choice in selecting the prescribed total number of hours or units which entitle him to a bachelor's degree. And this is a long step in the right direction. However, the important point is often overlooked as to whether the various so-called fundamental subjects really fit the student to pursue certain technical subjects with the greatest profit. It is readily granted that the pursuit of any really fundamental subject in science like chemistry, bacteriology or any of the various lines of botany, constitutes valuable training for the horticulturist, but the writer contends that the mere mastery of such a subject *per se* is not sufficient. To be really efficient, the college or department offering certain subjects at least, should, first of all, have the agri-

cultural viewpoint. This will not necessarily cause the subject matter presented to be any better, but the psychological effect upon the student is usually very marked. I have little sympathy with the tendency displayed in some quarters of trying to popularize science work. Pure science should remain pure and undefiled and no attempt should be made in a serious college course to sugar coat it, but it will do no harm occasionally to point out to the student in physics, for example, why it is bad practice to work certain soils while they are wet, or in plant physiology that it is necessary to trim the branches on a newly planted tree.

If the physicist or botanist does not know good examples for illustrating certain points in his work, then he should get closer to the horticulturist. On the other hand, the horticulturist should be on good terms with all the science teachers, chemists, geologists, botanists, etc.,—know what they are teaching and how the subjects are being presented, and in the course of his own instruction take particular pains to back them up and tie their subjects to his by calling the students' attention at every opportunity to the principles they have been studying and how they can be applied at every step in their horticultural work.

Preferably the teacher of horticulture should supply the botanist, chemist, etc., with a syllabus of his own courses and also secure outlines of theirs. This arrangement would provide opportunity for the highest degree of the right kind of cooperation for the good of our students. It is difficult enough at best to get the student to understand the necessity for spending so much of his time on the fundamental sciences. This is one of the main difficulties in the teaching of agriculture. In engineering he can readily understand why all his mathematical subjects are essential because they are used at every step. Our task is to teach our subjects in such a manner that the students will find it difficult to proceed without a good understanding of the sciences underlying agriculture. It is all important then to put forth every effort to get the students to appreciate the value of those sciences at the time they are pursuing them and this can best be done by inducing the teachers of the subjects to make an effort to vitalize their subject matter.

It is scarcely necessary to say that cooperation between the two arms of the college, the scientific and the technical, is possible only when the departments themselves are well acquainted and on the best of terms personally. After all it is not a question of syllabi and written agreements so much as it is a matter of sympathetic interest and mutual understanding. This interest of science in farming and of agriculture or horticulture in science, is at once reflected by the students. Students are quick to observe whether we really lean heavily upon our science departments and whether the science departments have a wholesome respect for us and our work. It is not enough to tell them in a sort of detached, academic way that it is absolutely essential for them to take more and more science and then proceed to give our horticultural courses in a way to indicate that we are all sufficient and could get along very nicely without the science departments. Think about this seriously,

you teachers. Have you been guilty of encouraging your students to take your technical electives when you well knew they ought to be taking advanced botany or chemistry?

The form of cooperation between departments discussed above was successfully carried out at the University of Missouri for many years and doubtless is still being followed. The same plan is now being put into operation at the University of California. At the latter institution the same general idea is being carried much farther, especially in experiment station work. Briefly stated, our legislature gave us a special appropriation of one hundred thousand dollars for carrying out experimental investigations with deciduous fruits. Some of these investigations are being conducted by the division of pomology alone, some by allied divisions alone (such as entomology, pathology, etc.) while others are cooperative. In all cases the projects are first approved by the division of pomology. A beginning has been made by actually assigning entomological and pathological men to work under the direction of the pomologists. This might be called team work, or in this case, cooperation carried to its logical conclusion. We first decide on our problem and then assign the right man or men to work on it regardless of what division of the college he or they may happen to be associated with. If the college does not have the right man then we go out and find him and set him to work. In carrying out these plans we do not consider it illogical to conduct our investigations with pear blight and root-stocks, for example, from the standpoint of the horticulturist, the fruit grower, rather than from the viewpoint of the bacteriologist or geneticist, although we do not hesitate to call upon those departments for advice and assistance. Verily, cooperation is a power if it be whole-hearted and thorough.

The same principles of cooperation and team work discussed above may be easily carried into the departments. This is especially true in station work. In most departments of horticulture there are usually too many unrelated projects under way. In fact it is a common mistake almost everywhere to have too many projects, anyway. How much better it would be to have only one or two major investigations under way and let the different staff men take part in the work as members of a team. Of course individual fitness and individual preferences of men must be taken into consideration, but the principle of successful team work is to make the men supplement each other as far as possible. One man may have had special advantages in chemistry, another in physiology, and another in plant or soil bacteriology. It stands to reason that these men working together will go farther toward advancing a problem than any one going it alone. The farmers of the state are not interested in whether it is a pomologist or some other ologist working on their problems. What they want is results.

Every problem has both laboratory and field aspects, or, its scientific and practical sides. The individualistic worker, the person who believes in "going it" alone, holds the perfectly beautiful theory that he will work out the fundamental aspects in the laboratory and then try them out in practice, or, first try out the practice work and

then investigate the fundamental questions he is sure to uncover. But the trouble with this plan is that life is too short or the tenure of office of the average worker is too brief. By teaming up we get results and, aside from the personal satisfaction of attainment, it is results that brings us support in the way of appropriations.

It is inevitable that important projects are always built around individuals. It is equally inevitable if that individual drops out the project will languish and die. This results in more or less loss in money and a still greater loss in valuable time. In team work, on the other hand, it is very improbable that all the workers concerned will ever drop out at any one time and if a vacancy occurs the gap can be filled by a new appointment or a readjustment of duties between those that remain. It is much easier to replace a single wheel than to set up a new machine. Of course the main difficulty in the way of team work in a department is the personal egotism of the workers. Too many men feel that they cannot afford to become cogs in the wheel or individual wheels in the machine. They fear they may lose their identity if they are not in full charge of some line of work. Likewise, they are apt to reason that they cannot afford to share the credit of attainment with others when they might have it all for themselves. And it is this hope of wholesale glory that causes men to want to have certain problems all to themselves when they are not big enough, or do not have the necessary time, to occupy the field they are trying to occupy.

In conclusion I may add that right now is the most favorable time we have ever known for instituting team work in both teaching and research activities. Large numbers of our young men have recently returned from war service and many of them were instructors in military camps. They saw and imbibed much of the spirit of getting things done as quickly as possible. For example, a youngster of my acquaintance, found that he could take a class of raw recruits knowing nothing about gas motors and in two or three weeks of intensive training not only make truck drivers of them, but make them competent to take care of their own repair work. I happened to be so situated as to see a good deal of the workings of a big school for aeroplane drivers. In common with the other observers I was much impressed with the marvelous results secured where science and practice went together hand in hand. The spirit of getting things done was infectious among the students and their interest in results kept them working at top speed at their tasks.

By a proper coordination of subjects and cooperation in subject-matter we can accomplish more than we ever have done before in our teaching and by a sane system of team work we can go farther and cover the distance quicker than we have ever dreamed of before in our station investigations. Then let us all pull together and introduce a new brand of efficiency in our colleges and stations. The net results, I fully believe, will be a better appreciation of our work on the part of the public and this in turn will be reflected in the better support of our institutions.

The Development of Practical Horticulture and Its Relation to the Farm Bureau Movement

By C. E. DURST, *Anna, Illinois*

THE writer of this paper assumes that every scientific worker in horticulture is interested in the development of his branch of agriculture, both from a scientific and practical standpoint. Otherwise, there would be no need of a discussion on the subject. The present manuscript has reference particularly to the development of the practical side of horticulture and its relation to the farm bureau movement.

The farm bureaus and the other organizations which have developed from them are giving practical agriculture the greatest stimulus it has ever received in this country. We have been accumulating information for many years, but farmers have not seemed to take hold of this as fast as some of us have felt they should. We have investigated, we have sent out bulletins by the ton, we have written articles for the farm papers, we have gone out into the country and given lectures, and yet the great majority of farmers have kept on in the same old way. It is no wonder that some men have considered the practical farmer as unworthy of their attention and have thrown themselves into the more scientific features of their work.

The developments of the past few years have shown that it is our psychology that was at fault. We have been trying to teach at a distance when it was personal contact that was needed. The farm bureaus have supplied this contact, and have thereby made themselves the connecting link between farmers in the field on one hand, and the department of agriculture and the state experiment stations on the other.

The growth of the farm bureau movement has been phenomenal. The first farm bureau was started in 1911. The number increased steadily until our entry into the war, when, due to the need for increased food production, the farm bureau organization was encouraged in every way possible and the number increased rapidly. On June 30, 1919, there were 1,106 counties with county agents at work in the 33 northern and western states, and these had a total of about 450,000 members.

The organization of farm bureaus in Illinois will be taken as an example of state development. The first two farm bureaus in Illinois began work on June 1, 1912. The number increased to 10 in 1913, to 19 in 1914, to 23 in 1915, to 28 in 1917, to 60 in 1918, and 15 more counties have organized since that time. The farm bureaus of Illinois had on December 1, 1919, a combined membership of 55,512 farmers, and the organizing force of the Illinois Agricultural Association is adding to this number by about 2,500 per week. From 90 to 98 per cent of the farmers in most counties are joining both the county farm bureau and the state association as fast as they are solicited.

The most important development of the past year has been the organization of state associations. These associations were organized to give farmers a means of taking care of their interests in competition with organized labor and capital. It is their purpose to handle problems which individual counties cannot handle. As an example of what these state organizations are accomplishing, please allow me to describe some of the achievements of the Illinois Agricultural Association since its birth last January.

It has been instrumental in framing and getting passed a pure seed law; in getting farmers exempted from the conspiracy act; in getting a bill passed regulating commission merchants; in securing a revision of the dog law; in helping to repeal the daylight saving law; in getting the bill passed which appropriates \$1,200 for each farm bureau per year; in getting a bill passed appropriating \$125,000 for enlarging the capacity of the limestone plant at Chester penitentiary, etc. It is said that the last legislature passed more constructive agricultural legislation than was ever passed before by any Illinois legislature. Along other lines the association has organized a wool pool in which 500,000 pounds of Illinois wool were marketed collectively; it has maintained a trouble man at Union Stock Yards; it is investigating the rock phosphate situation, etc.

A short time ago the secretary of the Illinois Agricultural Association in company with representatives of four other state associations in the Middle West, interviewed the President of the United States and laid before him the farmer's case with reference to the high cost of living. This is the first time in history that organized agriculture has done such a thing. Organized capital and labor have often done so. We shall hear more of farmers doing it in the future.

The state associations, as well as the county farm bureaus, have found their limitations, and to handle national problems the American Farm Bureau Federation was organized on November 12, 13, and 14, 1919, at Chicago.

The idea of state and national organization is appealing to farmers very strongly. Many farmers who were not interested at all in their county farm bureau have joined both it and the state association when the latter came into the field. Many county farm bureaus have doubled and trebled their memberships since the state associations were organized. The farmers, whom many people thought could never be pulled together, have suddenly taken a notion to organize, and the present indication is that they will make a thorough job of it before they are through.

I mention these things to bring out as clearly as possible the fact that the farm bureaus, and the larger associations which have developed from them, are live, going concerns. The horticulturist who does not comprehend the true nature of this movement, who does not keep himself informed regarding it, and who does not line himself up with it, will not do much for the advancement of practical horticulture.

The question is, "How shall we go about it." I do not presume to be able to exhaust the subject, by any means. The suggestions

which I shall offer for your consideration are made as a result of my nine years' experience in college, station, and extension work, and almost two years' in county agent work in Union County, Illinois.

NATURE OF FARM BUREAU WORK

In order that we may appreciate the problem, I desire to say a very few words about the nature of farm bureau work. A farm bureau is primarily an educational concern, but there is much in the work that is of a business nature. As an educational organization, it promotes better farming in every manner possible. From a business standpoint it assists farmers in locating and buying seeds, fertilizers, and spray materials, in marketing their products to better advantage, and in making a closer study of farm management. I confess I did not comprehend the business features of farm bureau work before I entered this field, and it is because I feel that other horticulturists also may not appreciate this phase of the work that I mention it. In fact, after my two years' experience, I am positively certain that the business side is fully as important as the educational side. Farmers appreciate this phase of the work very much indeed, both because service is needed along these lines and because the benefits are direct and can be seen in terms of dollars and cents. And after all this is the manner in which farm bureau work must be made to appeal to farmers. They are intensely practical. Any argument which does not stand the acid test of dollars and cents is not likely to meet with much favor.

EXTENSION MEN SHOULD WORK THROUGH THE FARM BUREAU

I desire particularly to emphasize that extension men work through and in cooperation with farm bureaus in counties where these organizations exist. If farmers have any confidence in their county agent at all, they look to him for agricultural leadership. Anything agricultural which is not presented to them through the farm bureau is not regarded as significant. They have hired the agent to look after their agricultural interests and they naturally suppose he is on the job.

This point is better illustrated by a case which came to my attention not long ago. A station man desired to hold a meeting in a farm bureau county to show the results of experimental work. Because of absence, the county agent could not cooperate in advertising and holding this meeting. The station man went ahead nevertheless. He had five farmers at his meeting. The county agent regarded the experimental work as very important and on his return arranged with the station man to hold another meeting and advertised the same. The result was 65 persons in attendance and a good meeting. A county agent usually knows the methods of advertising that bring results with his members. He knows the best time to hold such meetings, and if he is the right kind of man the farmers have confidence in his leadership.

In another sense it is much easier to work through farm bureaus. Under the old method we had to get acquainted when we arrived in a

county. We gave our lecture or held our demonstration, and after our departure we could simply hope we had made a good impression and that our recommendations would be followed. I dare say that many of you, like myself, have been disappointed to learn later that your efforts were soon forgotten.

Now, when we go to a county and work through the farm bureau, the county agent will have the way prepared for us; he will see that we are properly introduced; he will try to acquaint us with local conditions; and he will remain on the job after we are gone to help farmers pick out valuable features of our work and put them into practice.

Knowing what I do of county agent work after two years' experience, I would not think, if I were to go back into extension work, of going to a county where a farm bureau existed and not working through the farm bureau. The farmers will pay ten times more attention to their county agent if they have any confidence in him at all than to an outsider, and it is only pedagogical suicide to try to work in a county without doing it through the farm bureau.

THE VIEW POINT

Men who would do extension work must have the right view-point. They must neither under-shoot or over-shoot the mark. It is better to under-shoot than to over-shoot. If there is any doubt as to the view-point, the best thing to do is to spend a week or two with county agents in the office and field. In the main, it is elementary information that is needed. The vast majority of farmers did not get very far in school. They are busy people, and such a vast bulk of information is offered them through bulletins, farm papers, etc., that many of them are unable to assort the good from the bad.

I once heard a prominent authority state that the farmers had absorbed all of the elementary information and that it would tax colleges to the limit to gather information as fast as farmers would absorb it. I had left the farm only a few years before and I did not feel that farmers had advanced so rapidly in that time, but I had very great respect for the speaker and supposed that his information was perhaps better than mine. Now that I have been again in intimate touch with practical agriculture, I feel certain that one will never make a mistake by assuming an elementary attitude.

On the other hand, I do not wish to give the impression that there is no need of advanced information. We must remember that there are many farmers who have college degrees. No matter how much training a man may have had, he will find an opportunity to use it all in county agent work.

DEPARTMENTAL ORGANIZATION AND POLICY

It is difficult for government men to work in close touch with farm bureaus. Their work will probably always consist largely of campaign work, like that of eradicating barberry, in stimulating pure bred stock, and the like. It will be the duty of college and station men to maintain the closest touch and do most of the personal work.

So far as colleges and stations are concerned, it will probably be best for each department to maintain one or more men especially for this purpose. Some colleges are already operating under this plan and have what are called departmental advisers. It is the duty of the departmental adviser to co-ordinate the extension work of his department. He should have the various members keep him informed of any new developments in their specialties. He should get his department as a whole to adopt a definite policy in regard to recommendations. Either by personal work or by publicity he should attempt to get county agents to give uniform recommendations regarding the leading features of horticultural work. It reflects no credit on either the farm bureaus or on the stations and colleges when one county agent is recommending lime-sulphur and the agent of the next county Bordeaux mixture for the same purpose. It is not at all uncommon for advisers in different counties to be giving different recommendations. The departmental adviser can do a very great service by getting his department to ascertain the best practices and then handing this information on to the county agents.

The work of the departmental advisers with the farm bureaus will consist of personal work and publicity.

PERSONAL WORK

The nature of the personal work will depend on the condition of horticulture in the various counties. In a county where horticulture is well developed, one may enter into scientific details, both with the county agent and with growers. Extension workers usually prefer to work in such counties, and they are likely to under-estimate the importance of their work in other counties. In counties where general farming prevails, there may be little interest in horticulture, and yet the opportunity is often very great in such places. The work there will need to be almost entirely of an elementary nature. In such counties even the county agent may not consider horticulture worth much effort, but tact and perseverance on the part of the department adviser will usually find a way of getting results.

The nature of the personal work will consist chiefly of consultations, lecture work and demonstrations. Regarding consultations, the county agent cannot be a specialist along all lines, and he frequently needs assistance on special problems. In many cases special problems can be settled by correspondence, but in some it is necessary for the departmental adviser to make a special visit. Consultations of this nature are not only helpful to the county agents and to the farmers, but they provide an excellent means for department men to keep in touch with conditions in the field. Many serious pests and other farm troubles have been discovered in this way.

Regarding lectures, the departmental advisers will be limited in what they can do. Their lectures will necessarily be along lines in which the adviser is not well trained. These may be given at short courses, farmers institutes or special meetings.

Too much attention cannot be given to the lectures. They should be clear-cut and free from involved details. A man should speak in the language of the farmer. He should use as little technical language as possible. Lectures are always better received if illustrated by lantern slides or other material. The old saying that 90 per cent of our knowledge is gained through our eyes certainly has a lot of truth in it. The preparation of lectures for farmers should receive the most careful attention.

Besides doing what lecture work they can themselves, extension workers can assist materially by preparing lantern slide lectures and loaning these to county agents. The capital of the average farm bureau is limited. Slides become practically obsolete as soon as they are used once throughout a county in a series of lectures. Consequently a farm bureau is likely to buy slides dealing only with subjects most important in its county. Since horticulture is not the leading phase of agriculture in most counties, slides along this line are likely to be neglected.

If departments would prepare sets of slides along the most important lines, it would help to solve these obstacles and at the same time would result in greater public economy. If department funds are limited, a rental should be charged to help pay for the slides. I am sure the average farm bureau would prefer this method to that of purchasing the slides.

The lantern slide lecture is not being used by county agents as much as it should be. It is a tremendously valuable method of education and would be employed to greater extent if the United States Department of Agriculture and colleges and stations generally would co-operate more fully in preparing and loaning slides.

What is true of slides applies also to moving pictures. This feature is rather new as yet so far as agricultural education is concerned, but when properly developed it is certain to fill a most important place. It is not too early to be giving serious thought to it.

There is also need for other illustrative material, such as specimens of garden and orchard insects and diseases, plans for storage houses, charts and pictures for county fair exhibits, etc.

THE USE OF DEMONSTRATIONS

Farm bureaus offer extension men an opportunity to make use of demonstrations. These are not feasible to any great extent in counties where farm bureaus do not exist, but they are quite feasible and extremely effective in counties having such bureaus. In these counties the county agent knows what demonstrations are likely to prove most worth while. He knows where they should be conducted, and he remains on the ground to help farmers make the maximum practical use of them.

The demonstration method is one of the most valuable features of extension work because it appeals to the eye. Some farmers can be convinced by argument and persuaded to try new things, but most of them want to see the results before they will leave the beaten path.

The value of demonstration is well illustrated by an experience I had. While connected with the Illinois Agricultural Experiment

Station, I wrote a circular on "Soil Fertility from the Vegetable Growers' Standpoint," in which I recommended hairy vetch as a cover crop very strongly. When I began work in Union County in 1918, I found that only two or three men had grown the crop and I do not know that any of them received the suggestion from me. I succeeded in getting three farmers to plant vetch in the fall of 1918. The crop did well, and as a result, over 8,000 pounds of vetch seed were planted the past Fall. There is no question in my mind but that the three practical demonstrations caused more hairy vetch to be planted than perhaps the tons of Circular 198 which were sent out.

The kind of demonstrations will be divided between methods of procedure and field operations. Demonstrations of method will consist of things like the making of spray material and its application, laying off and planting an orchard, and methods of grading, packing, etc. Demonstrations of field practice will consist of such things as tests of fertilizers, methods of cropping, tillage and variety tests of vegetables.

In planning demonstrations (for the start at least) it will be well to arrange for those that will show the greatest differences. As already stated, farmers want to see results, and they are not seriously impressed with things that are not plain to the eye. If one can show marked results at the start, he will gain the farmers' confidence and they will then lend an ear to results that are not so plainly seen by the eye.

PUBLICITY

The publicity methods of department advisors are quite as important as the personal work. Through the right kind of publicity, much can be accomplished that is otherwise impossible. It behooves each man to ascertain the methods that are most effective under his circumstances, and then to get the proper balance between them.

To publish effectively, one must know how to write. Some persons are naturally better qualified along this line than others, but no one should feel there is not room for improvement. It would be a fine thing if all extension workers could have taken courses in journalism and advertising.

In any kind of publicity, one must remember that it is the written word only that is speaking for him. In personal work, the personality of the man, the modulation of the voice, the expression of the eyes, and so-called diplomacy, can be brought into play, but in publicity work these are largely lacking. One must put his personality into his writings. The extent to which we can do this will determine whether or not our letters and other forms of publicity will bring home the results desired.

If extension workers get themselves properly connected, they will receive many letters, both from county agents and farmers. Answers should be made promptly. Very often hundreds of dollars in money are involved, and whether or not it will be accredited to the profit or loss side will depend on the promptness of the reply. Nothing is more discouraging in the field than to receive a week or two late a letter that should have been answered in two or three days.

Personal letters should be as brief as is consistent with completeness. They should contain the information desired. I once received a reply to an inquiry, directing me to consult Bailey's Encyclopedia. If this did not contain the information desired, it was suggested that I write to the New York Botanical Garden. I happened to own a set of the encyclopedia but I might not have done so. It did not contain the information desired. Now I am positively certain that this man had the ability and the library facilities to give me exactly the information wanted, but he did not give it.

The circular letter, properly used, is an effective source of advertising. One should use it only when he has something important to say. County agents much appreciate short snappy articles on subjects pertinent to the season. They will often incorporate such statements bodily in their circulars or news bulletins to farmers. If the article is so long that it has to be remodelled or boiled down, this will reduce the extent to which the material is used.

To ascertain the kind of article desired for county agent circulars, it would be well for each departmental advisor to ask county agents to place him on their mailing list. I know of no better means of learning the kind of publicity that is effective with farmers and county agents than to study these circular letters and news bulletins.

State extension departments, as a rule, send out news bulletins regularly to county agents. The right kind of articles in these constitutes an effective method of reaching county agents and farmers.

It seems to me that these publications are often used too largely to record mere field experiences of county agents. In my opinion they should be employed mainly to summarize scientific information that can be put to practical use.

A great deal could be said about experiment station circulars and bulletins. I am convinced that many stations are right in not sending large bulletins to the general mailing list. Farmers simply will not read them. County agents have little time to read lengthy publications. Short bulletins that summarize the long ones are to be commended, and short snappy circulars describing principles are extremely valuable. The county agent will usually have time to read these, and they are particularly well adapted for enclosing in circular letters to farmers.

I realize that in this paper I have covered the ground only in a general way. I have tried to show that the farm bureau movement has reached enormous proportions in the past few years; that it promises to continue to grow rapidly; and that it brings new responsibilities and new opportunities to extension workers. The extent to which extension specialists get their departments to comprehend this movement and line up themselves with it, will determine the practical development of their phase of agriculture. It will also determine all other development, for as farmers become more thoroughly organized, they are going to take more and more of a hand in matters of business and legislation. Departments that do not maintain the proper connections with farmers in the field, are certain to suffer financially sooner or later.

The County Horticultural Agent

By A. R. JENKS, *Waltham, Massachusetts*

THE county horticultural agent is brother to the county agricultural agent. His job, his value, his relationships to other horticultural workers and results accomplished are similar to those of the county agricultural agent in his field. The county horticultural agent is having a wholesome influence on men engaged in horticultural research and teaching because of his closeness to the practical horticulturist.

The county horticulturist is supplying the missing link between the horticultural research men with their wealth of available information and the practical horticulturist, who, as a rule, obtains only a small per cent of this material in a form that he understands and will put into practice. The horticultural workers in a state should have at least an annual conference for the purpose of interchange of ideas and so that they may all agree upon subject matter.

The county agent movement has grown rapidly within a few years. Work accomplished to date justifies all hope placed in the movement. The work is becoming more efficiently managed. The farmers are now as a class strongly behind the movement. Those sections having a special horticultural interest deserve a specialized worker.

In counties having a large interest in fruits, flowers, or vegetables, or where possibilities in one or more of these lines are especially pronounced, the horticulturist should be able to make his efforts worth while within a short time.

In counties where only one worker may be employed because of lack of funds, the man employed often is one who has had special training, practical experience and interest in horticulture if conditions in the county are preeminently horticultural. This method does not often prove satisfactory because such a man must of necessity spend considerable time on projects other than horticulture. In a county where horticulture is a major interest the growers are quite apt to be very well posted and expect of their county agent some real leadership along very advanced lines. An agent is not often in a position to do this when it is necessary for him to handle general agricultural projects as well as specialized horticultural projects. There are few sections but where two or more nearly contiguous counties might not unite and cooperately employ a horticulturist. Where this idea is not feasible, it may be possible to employ some local, practical, successful horticulturist on part time. Fortunately, in most sections can be found a man who feels that the dollar is not the only object to be obtained in life and is willing and anxious to do some public work.

The county horticulturist is primarily an extension man, but this article does not call him that because quite often local problems necessitate his broadening his sphere of activities so that they enter

the field of research, teaching and propaganda. In many counties where the agent is co-operatively employed and Smith-Lever funds used in partial payment for his services, he naturally must confine his efforts to extension work.

It seems that one of the big reasons why the county horticulturist idea is likely to be so successful, is the fact that the man covers less territory and is enabled to do proper follow up work. He knows his local people personally, their local conditions, their personal limitations and cannot therefore help but be more practical in his suggestions.

Numberless cases are recalled where suggestions have been made and received in good faith by the farmers. In many cases, the farmers have started to carry them out, but have encountered slight difficulties or hindrances. An incidental follow-up call by the county specialist shortly afterwards at the right time has oftentimes resulted in helping the situation and the projects have been carried through.

The county horticulturist, even though a specialist, finds it difficult to get around the county and meet all of the men personally who would welcome a farm visit from him. This therefore makes it necessary to do much of his project work through local leaders and local committees. These local leaders meet in county conference at least once a year and in sectional conferences several times during the year. They are visited frequently by the county specialists, this giving an opportunity for the straightening out of any misunderstandings, the explaining of all details, and the prodding along of those who are somewhat backward in getting into action.

The local horticultural leader is a member of a town bureau committee of which other members represent agriculture, boys and girls' club work, dental clinic, home economics and any other line or lines of bureau work being conducted in the community. The local horticultural leader associates about himself a committee which represents different lines of horticultural interests in the community, or different parts of the town, or both. During late fall these committees meet for the purpose of reporting on results of projects undertaken during the year in the town, and for the purpose of framing a program of work or set of projects for the coming year. The local leaders in annual conference bringing in their local projects assist the county horticulturist in framing a set of county projects. Many of the local projects apply strictly to their respective communities and cannot be adapted into county projects. It is interesting to note the similarity of projects developed locally by the practical orchardists and gardeners. This year, nearly every community in Middlesex County, Massachusetts, is asking for a project on bees although not a community requested such a project last year.

There should be the best of co-operation and team work between the several county horticulturists in a state, the state extension horticulturist, the experiment station horticulturists and the federal horticulturist in charge of demonstration work.

Horticultural work in any state could be materially benefitted by having a conference of all those engaged in the work at least twice a

year. In this way the extension workers will agree on subject matter of their teachings, obtaining much of the newer ideas and recent information from the research workers. The research workers cannot help but obtain suggestions for future lines of work from the discussion brought out from the extension workers of both state and county.

One of the big fields of usefulness of the state extension horticulturist at present is to keep in touch with all advanced ideas over the country and to sift out those which probably will not apply locally. Intensive extension work may well be done in those counties not blessed with a county specialist.

It is believed that if a goodly number of horticultural research men could only spend a year as county horticulturists, or spend a year working with county horticulturists, their lines of work at the experiment stations would be changed a great deal. County horticulturists working with the farmer in the field roughly two hundred days a year, come pretty near seeing the different problems from the farmer's view point. They soon realize what a small per cent of the work being done at the experiment stations really tends to solve what the farmer considers present day problems, or what are likely to become problems within a few years.

Another regrettable condition is the fact that results of really worth-while experiments, worth untold dollars to the farmers if they were to put them into practice, really reach a very small per cent of the farmers. County horticulturists and state extension horticulturists, are partly to blame for this condition because one of their big jobs is to interpret results of experimental work and take these results and recommendations to the farmers. Should not experiment station workers, however, get out their circulars and bulletins in a manner so as to be more easily understood by the lay farmer? There is a strong tendency in this direction. The experimentalist probably feels that he has gone far enough in this direction, but the fact remains that the farmer whom his work is supposed to benefit, is really obtaining very little of the result of his fine work.

Horticultural teachers who have been called upon to do much of the state extension work during the last few years, have come into close contact with the farmers and have modified their teachings, making them much more practical and valuable both to the farmers and the students in the college classroom.

Some of the definite projects developed last winter by the farmers of the county and which have been under way during the season as Middlesex County projects follow:

1. Relative to Fruits.

- a. Encourage planting of apple trees, especially Red Astrachan, Wealthy, Gravenstein, McIntosh, and Baldwin in sections favorably adapted to their culture.
- b. Encourage general and better pruning.
- c. Place emphasis on thorough, oftener, and more intelligent spraying.
- d. Encourage increased use of nitrogen in mature as well as young orchards.
- e. Encourage breaking up of sod in orchards which are more or less starved and in need of general waking up.

- f. Encourage thinning practice on heavy bearing varieties to get high quality fruit.
 - g. Render service to individuals and communities interested in developing individual and co-operative apple storages.
 - h. Promote an interest in the commercial manufacture of apple and other fruit by-products, such as apple juice, apple-butter, etc.
 - i. Undertake the Littleton fruit survey.
 - j. Conduct two automobile excursions to orchards which illustrate different types of orchard practice.
2. Berries.
 - a. Recommend no more planting of currants and gooseberries until more is known about the possible control of white pine blister rust.
 - b. Encourage planting of raspberries.
 - c. A blackberry planting campaign is recommended.
 - d. Indications point to the fact that profits on strawberries will increase their acreage, thus taking care of any likely shortage.
 3. Vegetables.
 - a. Encourage those interested in producing their vegetable seed requirements.
 - b. Encourage the use of tarred disks for the control of cabbage root maggots.
 4. Marketing.
 - a. Help in the general plan of creating favorable sentiment to co-operative farmers' exchanges. These will ultimately buy raw materials, machinery and accessories and market their entire line of produce.
 - b. Encourage co-operative grading, packing, hauling and selling of farm produce.
 - c. Study and recommend methods of packing and packages which will help retail roadside stands and other marketing.
 - d. Teach consumers the value of fruit and vegetables as a food and thus increase the consumption of same.
 - e. Help individuals with their marketing problems before they are ready to market through co-operative exchanges.

Some Indirect Methods in Extension Horticulture

By H. A. CARDINELL, *University of Missouri, Columbia, Mo.*

THE agricultural extension worker is frequently confronted by certain phases of work which may be classified as indirect in-so-far as these calls tax the ingenuity of the director and the specialist in order to make them fall within the bounds of the "Smith-Lever Act." Extension service, in the strictest sense, should be with the grower or farmer, but many times work with drug stores, seed houses, hardware stores, etc., in getting horticultural equipment on the

markets and encouraging its display at the proper seasons, will be of more direct aid to the fruit industry and to the grower than a year of demonstrations that have not been preceded by similar educational features with local merchants; not with the idea of being an advance salesman, but to point out types of equipment suitable for local needs.

The object of this paper then, for the most part, is to record some of these problems as they are found in the state of Missouri, well knowing that many of the topics set down in this paper have been worked out in other states; but that those present are interested in the manner in which Missouri is attempting to attack some of the extension problems in horticulture.

Missouri has enjoyed in the past, a rather unique position as a deciduous fruit state and especially with this true as regards the apple. The 1910 census credits Missouri with over 14,000,000 apple trees of bearing age. However, within the past 2 years this state has had a rude awakening to the fact that it was not as great a factor in the fruit industry as the figures of its bearing acreage led Missourians to believe. Only recently the State Board of Agriculture issued a preliminary statement that there are less than half the number of bearing apple trees to be found in this state at the present time than there were in 1909. Missouri had an unusual condition perhaps not equalled in any other state, in that her enormous bearing apple acreage was made up in the main, of home orchards due in part, to the large foreign born element which planted home orchards varying in size from one to ten acres, and while this accounts for the large fruit acreage recorded, it likewise accounts for the low ranking Missouri has had in the matter of commercial production. This likewise accounts for the rapid reduction of acreage recorded recently as a result of the rapid dying-out of home orchards due to neglect and mismanagement.

This, then, gives a clue to the peculiar condition confronting the extension service in the working out of its horticultural projects and accounts for the large number of indirect methods that must be employed in this state to meet the needs of the fruit interests.

Spraying as practiced in Missouri is still in its infancy. This is mainly true in the case of the farm orchard, and is, to only a lesser degree, true on the large fruit plantation. The main difficulty found here, is not that the commercial grower does not apply the prescribed number of applications, but that he lacks thoroughness as shown by the small amount of solution administered per tree of a given size, as well as in the manner of application.

The poor distribution of spray materials on our markets has always embarrassed the extension horticulturist. He has too often, during the past season, been compelled to carry, or ship in advance, sufficient material for putting on a demonstration in localities not having sprayed before, and where no ingredients save Paris green could be had upon those markets. This was especially true in the watermelon section of this state during last season when the first spraying was begun in two counties that had never sprayed a vine, but from which counties nearly three thousand cars of water-melons

were shipped. Such a campaign greatly taxed the central office to interpret it so as to be within the realm of the Smith-Lever Act as it hardly falls within the clauses, working "directly with the grower" but is so indirectly vital that it must be conducted before a satisfactory working "directly with the grower" can be accomplished. As a result of the extension specialist not finding any or the proper material on the markets of many localities in which he is called to work, he has launched a campaign, in all counties having a county agent, whereby the specialist shall furnish each county agent, or any individual so requesting, a memorandum containing a list of firms handling or manufacturing spray materials and the retail prices of same. Before launching this campaign the writer secured the promise of a majority of manufacturers to furnish him with retail and wholesale prices of spray materials and to keep him informed of every change in price as such may fluctuate. The wholesale price list is to be furnished only by county agent or specialist to the dealers in each locality, on request. In order to avoid delay in spring work when dealers have not secured prices, the county agent will show them the wholesale list from which they may order by wire, if need be, and can at the same time determine their retail price to the buyer. What has been arranged with regard to spray materials has also been arranged with the companies manufacturing spray machinery and is embodied in the memorandum to county agents.

Pruning is almost a lost art in Missouri and I venture the statement that over 90 per cent of the bearing trees in this state have not been pruned in the last 10 years. Almost the entire stress of extension horticulture has been on spraying since that was the one practice that was sorely needed and could give convincing results in one crop season. But now we have reached a point when spraying enthusiasm is running under its own momentum and we are launching a pruning campaign this season which necessitates furnishing the county agents the names and prices from companies manufacturing or handling these commodities and will aid in educating the merchant on the best types to carry in stock and should thus be of direct help to the grower and greatly lighten work of the county agent.

In the past the co-operation both in pruning and in spraying has been mainly of a demonstrational nature with the specialist doing all the work; but this season we have altered this policy and the specialist carries with him enough shears and saws to put on a practical demonstration, and after pruning one or two trees, each man present who owns an orchard is given a tree to prune while the specialist remains on the ground assuming the role of an orchard manager training a pruning crew at the beginning of a season. Thus our growers are given in opportunity to make the cuts themselves and on returning to their orchards will have the confidence in their ability which no amount of demonstration or illustrated lectures alone could equal. Supplying demonstration tools is not an indirect method of approach, but recorded as a suggestion worth mentioning.

The horticultural department and the extension service are working in unison to endeavor to prevent the neglect and cutting out of

bearing orchards by acting as a clearing-house for orchard owners wishing to sell, lease or rent their orchards. We do not pretend, or wish to compete with, or act in the capacity of a reality firm, but deem it the business of a horticultural service to give assistance to the industry. We are no more trying to antagonize the real estate offices than any department keeping a record of its graduates for purposes of position recommendations, is thinking of antagonizing employment bureaus and teachers agencies. Also the Missouri State Horticultural Society and State Board of Agriculture are aiding greatly in this work by publishing in their regular news letters the names and addresses of such parties.

There are often items of vital horticultural importance and of enormous direct benefit to the fruit grower, that could not be undertaken by the resident or extension staff as they would bring down upon the institution a flood of criticism by commission merchants, brokers and manufacturers; yet such work can be gracefully and diplomatically conducted by state organizations such as state horticultural societies and farmers and growers clubs. With this in mind the horticultural service aided the Missouri State Horticultural Society in compiling in the form of a news letter authentic records of fruit sales giving locality, variety, and price received, so that small growers not familiar with trade channels and market conditions could estimate the value of their own fruit by comparing the quality and sale price of the fruit sold by their neighbors. The success was remarkable in that it proved to the commercial grower that the State Horticultural Society could be of real service to him and as a result many large growers renewed or took out membership in the society and thus the society reached the ear of the commercial grower and became a sounder organization. Incidentally by the horticultural division supplying the material the state society becomes more closely linked with the horticultural division and the benefits to each are mutual.

Last year the extension department endeavored to place a woman horticulturist upon its staff, but it could not be realized and is hoped for in another year. The plan was to employ a home economics graduate who had specialized on fruit by-products, to work among the homes just as women specialists assist the home demonstration agents. A woman fruit specialist could greatly increase the consumption of fruits by teaching the proper time to preserve each fruit in its season so that the housewife would know when each fruit is most plentiful and what varieties are best suited for each purpose. Very few homes know the varietal adaptability of each fruit for preserving purposes. This same specialist during off-seasons of the year could devote her time to research work in the horticultural and home economics laboratories studying the local characteristics of each variety for stated purposes. It matters not whether she be in the home economics extension department or in the extension horticultural department, but her work would be of direct benefit to the grower. A woman fruit specialist could double or triple the amount of fruit consumed in the home in a given section and also be of great value to the housewife and consumer in getting more

value for a given amount of money spent on the right sort of fruit when selected judiciously.

Thus far very little has been done along marketing lines by the extension service because production and better fruit were first needed before any fruit marketing organization would dare venture forth with a labelled product when no standard fruit was being produced.

Another item in indirect extension horticulture which we plan to launch at the time we venture upon a state-wide marketing campaign within the next two years, is the too often neglected fruit display; not so much in the matter of state or local fairs, but in the state-wide display of fruits in local store windows. Here is a splendid opportunity for the woman specialist and extension horticulturist to combine on a very effective piece of extension work. The artistic taste and training of the woman specialist would neutralize the crudely practical ideas of the horticulturist. Extension salesmanship and fruit displays would make a very timely course in any horticultural department and is an oft neglected line that even our more specialized fruit districts throughout the United States have not given sufficient attention, if any, due to the concentration on production, handling and marketing issues. Along this line extension horticulturists could wisely follow the suggestions of the California Fruit Growers Exchange in conducting a display campaign. Some very timely hints are offered in its recent booklet "Salesmanship in Fruit Displays." A fruit sermon is to be found in the statement, "Goods must be displayed to be sold and must be sold to be displayed." In order to have attractive displays of fresh fruit it is necessary to have a rapid turnover and to sell fruit it *must* be displayed. The Exchange also advocates that stores be induced to offer local premiums for fruit baskets and window displays to encourage *local grown* fruit displays, which means increased consumption. Another timely suggestion is the use of more basket window displays to suit the needs of each purchaser, such as traveler size, hospital size and home sick friend and gift size. Its ideas on "The Importance of Turnover" are as readily applicable to deciduous fruits as to citrus fruits when it states "you know that rapid turnover is the secret of success in business. But do you know that in the case of oranges and lemons (apples and pears could readily be inserted) it can be made to pay you more profit than almost anything else?" It also says, "when sizes run small special peck or bushel sales of small or mixed sizes will sell larger quantities." "If prices are high offer in less than dozen units, and when prices are low sell two or three dozen to a customer at a time." This salesmanship education is a distinctly indirect subject yet it can not be overlooked and must become the work of the extension specialists in any large fruit section.

Both community and group spraying plans are very applicable to this state as the enormous number of farm-orchards might indicate. We are encouraging this year more than ever before, the cleaning up of these orchards by the group and community plan rather than advocating a barrel pump for each farm. The slowness, low pressure, and tiresomeness developed by the barrel pump have never made an

enthusiast of any home orchardist. Therefore, we are taking advantage of the psychological factor produced by the past few seasons of good fruit prices, to encourage the employment of small power outfits by neighboring groups. Thus far our success has been highly encouraging and the most popular outfit seems to be the \$195 to \$295 models of barrel pump with pump and engine mounted on skids as manufactured by Hayes and other companies. Such a campaign can have no other effect than to produce better local fruit and reduce the risk of the commercial orchard and the new plantation.

The Need of Vegetable Investigations

By J. W. LLOYD, *University of Illinois, Champaign, Illinois*

WITH a view to securing information regarding the nature and extent of vegetable investigations that have been conducted within recent years, files of the Experiment Station Record have been examined, and all reports of actual experiments or investigations regarding vegetables, during a period of six years, have been noted. To avoid possible complications due to war conditions the six-year period from 1909 to 1914 inclusive was chosen. Foreign as well as American investigations were included.

An examination of the data thus secured shows that a total of 206 items regarding vegetable investigations were reported. In making this count, whenever two or more kinds of vegetables were involved in the same report, each kind was recorded as a separate item. Classifying the investigations roughly they may be grouped as those concerned with (1) breeding, (2) culture, (3) fertilizing, (4) disease control, (5) insect control, (6) variety studies, (7) chemical composition, (8) marketing, and (9) storage. However, 170 items out of the total of 206, were concerned with breeding, culture, fertilizing, or disease control, leaving only 36 items distributed among the five other groups mentioned. Studies regarding marketing or storage were included in only seven items.

Thirty-seven different kinds of vegetables are mentioned in the reports, but 13 of them are mentioned only once, thus leaving only 24 kinds of vegetables concerning which there are two or more reports. However, some of these vegetables appear much more prominently than others. For example, 3 vegetables stand out conspicuously above all the others and account for 85 of the reports. These are tomatoes, cabbage and beans. If cucumbers and melons are added to this list, the 5 vegetables account for 105 of the reports or over one-half the total number.

There are 52 reports on breeding experiments; 22 of them deal with tomatoes, beans or cabbage. Out of 47 reports regarding disease control, 32 deal with tomatoes, beans, cabbage, cucumbers or melons. Nineteen reports of variety studies are made; fifteen of these deal with tomatoes, cabbage or beans.

These citations show that much of the investigational work with vegetables has been confined to a small group of plants. Many important vegetable crops have apparently received relatively little attention. Besides the 13 crops which are mentioned only once, there are at least 23 other vegetables of distinct importance which are not reported at all. That is to say, out of 60 vegetable crops which a fairly comprehensive list would certainly include, 36 are either omitted entirely or mentioned only once, in the reports of investigations recorded during a period of six years.

Very much less prominence is given to vegetable investigations than to fruit investigations. A fair estimate, based upon the reports appearing in the Experiment Station Record, would be that about 6 times as much attention is being given to fruits as to vegetables. This difference cannot be accounted for by any corresponding difference in the value of the fruit and vegetable products of the United States; for as a matter of fact, the value of the vegetable crop of the United States far exceeds that of the fruit crop, including all orchard fruits and small fruits, citrus fruits and grapes, subtropical fruits and nuts. Nor is it reasonable to assume that the disparity in the amount of investigational work being devoted to fruits and to vegetables is due to any corresponding lack of need for investigations with vegetables.

Among the lines of work with vegetables needing the attention of trained investigators at the present time, the following may be mentioned:

1. The nomenclature of vegetable varieties is in woeful need of simplification. This will require the combined efforts and co-operation of station workers, seedsmen and commercial growers. The Vegetable Growers Association of America has a committee working on this matter, but it needs the support of everyone interested in vegetables. It can suggest what ought to be done, but little actual progress in the accomplishment of results can be made by this committee alone. Systematic studies of vegetable varieties and strains should be given more attention by station workers. I do not refer to general variety testing as an incidental side line by an already overworked station assistant, but to intensive study of a given group of plants by an individual who understands the peculiarities and possibilities of that particular group. We need more studies like those reported by Tracey in Bulletins 69 and 109 of the Bureau of Plant Industry, dealing with varieties of lettuce and beans respectively. If the report is true that the Bureau of Plant Industry contemplates discontinuing studies of this sort, the American Society for Horticultural Science, as well as other organizations interested in the vegetable industry should pass resolutions setting forth the importance of such studies and urging their continuance.

2. The structure and composition of vegetables need careful study. Such studies should include a determination of differences in the structure of tissues of different varieties of the same vegetable when grown under similar conditions, and differences in the structure of tissues in the same variety when grown under different conditions. Particular attention should be given to differences in structure

influencing the texture and quality of the product. Causes of difference in flavor should also be determined. The response of vegetables to their environment as reflected in their quality should be given careful attention, so that the influence of richness of soil, intensity of light, degree of temperature, amount of moisture, and severity of crowding, upon the quality of a given vegetable may be known with a fair degree of accuracy, to the end that vegetables may be grown under conditions most favorable to the development of a product of high quality. Furthermore, the chemical composition of vegetables needs detailed study. Reports of analyses available at present usually fail to state the variety, degree of maturity, or the condition under which the product was grown. There should be definite information made available regarding the influence of environment and other factors on the composition as well as structure of the different kinds of vegetables. Not only should analyses be made of the edible portion of a vegetable as a whole, but separate analyses should be made of the various parts, to be used as a basis for selection and breeding to increase the relative size of a given desirable part or decrease the relative size of a less desirable part. The work of the Illinois Station in the breeding of field corn indicates the importance of chemical analysis of the various parts of a food product as a basis of selection for improvement in a given direction. It is probable that separate analyses of the core and cortex of carrots, parsnips, and vegetables of similar structure might be made to serve as a basis of selection for improvement of these vegetables in nutritive value. We need to know more about the food value of the various vegetables, the influence of conditions of growth upon their food value, and the bases of selection for improvement in both their palatability and nutritive value.

3. Breeding for the production of varieties adapted to particular purposes or conditions should occupy more attention. Definite breeding work has for the most part been confined to relatively few different kinds of vegetables. In many cases, the development of improved strains of existing varieties will be much more important than the production of new varieties. However, there is always room for varieties that are better than existing sorts in some important feature, such as productiveness, earliness, size, quality, etc., and such varieties might better be produced as a result of systematic breeding, rather than be accidentally found.

4. Studies in disease resistance and disease control should be extended to a wider range of vegetable crops. Much work has been done on a few of the more important crops, and a few disease resistant strains have been developed, particularly in cabbage, muskmelons, and tomatoes. Work of a similar nature should be attempted with all vegetable species that are subject to destructive disease attacks which do not yield readily to fungicidal treatment or other means of control. Studies should also be made in methods of combating diseases of the minor crops by spraying and other methods of treatment. Of course, it is understood that life history studies of the organism causing the disease will go hand in hand with the study of control measures.

5. Fertilizer experiments with vegetables have been quite numerous and have covered a fairly wide range of crops. However, such experiments have been confined largely to the East and the South. A new condition confronts us in the Middle West. Vegetable growers in this region have in the past depended mainly upon stable manure to keep up both the plant food supply and humus supply in their soils. The general introduction of motor driven vehicles in the cities and towns has so seriously affected the supply of horse manure available to gardeners, that a change in fertilizing methods seems unavoidable. Unfortunately, few tests have been made to determine the feasibility of maintaining the fertility of garden soils in this region without the use of animal manures. A start was made in this direction by the Illinois Station in 1917, the test, however, being limited to three important truck crops. So great seems to be the need of a comprehensive fertilizer experiment to test the possibility of substituting cover crops for manure as a source of humus, and commercial fertilizers for manure as a source of the mineral elements for the production of vegetables in the corn belt, that the Illinois Station is planning a long-time experiment with a number of vegetable crops with a view to securing definite data on this important subject.

6. Problems connected with the handling and storing of vegetables need attention. Antiquated methods of storage still prevail in many producing regions. The work of the United States Department of Agriculture and the experiment stations of some of the southern states in introducing improved types of sweet potato houses, and the proper curing of sweet potatoes, bids fair to revolutionize the sweet potato industry of the southern states. Experimental work in the storage of certain other vegetables has also been undertaken. Such storage investigations should be continued and also extended to include other vegetable products, with a view to eliminating as much as possible of the shrinkage and waste which obtain under present storage methods in many places.

7. Closely allied to the matter of storage is the entire problem of keeping perishable vegetables in a fresh and sound condition from the time they leave the producer's hands until they reach the consumer's kitchen. Transportation and refrigeration facilities need to be improved. The investigation of the United States Department of Agriculture in regard to refrigeration in transit will likely lead to improvements in refrigerator car construction, and methods of loading and icing. While most of this work has been done with fruits, the principles involved will doubtless apply to many vegetables also. However, vegetables that reach the wholesale market in sound condition sometimes deteriorate badly in the hands of dealers, especially retail dealers. Thorough investigations should be made to determine the best and most feasible methods of keeping the various kinds of vegetables fresh and sound while in the hands of retail dealers. The enormous spread between wholesale and retail prices of perishable vegetables is attributed partly to the loss due to deterioration and spoilage while the products are in the retail store. Such loss could be largely eliminated by proper methods of protec-

tion from exposure to unfavorable conditions. The most feasible means of protection of these vegetable products could readily be worked out by properly conducted tests and investigations. The introduction of the improved methods could be made to follow after their value has been fully demonstrated. Much loss of perishable products in the hands of retailers could thus be eliminated.

SUMMARY

I have touched briefly upon the need of investigations (1) regarding the present situation in reference to vegetable nomenclature and the study of varieties; (2) regarding the structure and chemical composition of vegetables and their parts; (3) regarding the breeding of vegetables for the production of varieties with special adaptations, and the development of improved strains of existing varieties; (4) regarding disease control; (5) regarding the plant food requirements of different vegetables, and especially the working out of a method of maintaining if possible the plant food and humus supply in a vegetable soil without the use of animal manures; (6) regarding the storage of vegetables, and (7) the preservation of perishable vegetables in transit and in retail establishments. The investigational work that has been done with vegetables up to the present time has been confined largely to a rather limited number of crops. This work should be extended both as to range of subjects involved and number of crops included.

The Uselessness of Hill Selection Under Conditions Where Rapid Degeneration or "Running Out" is Prevalent*

By R. WELLINGTON, *Maryland State College, College Park, Maryland*

IN 1913, when the writer took charge of the Section of Fruit and Vegetable Investigation at the Minnesota Agricultural Experiment Station, he found that potato varieties had been degenerating or "running out" very rapidly for many years at the University Farm. The trouble was not wide-spread for growers located only a few miles away were free from such an affliction. Since strong, medium, and weak hills were often produced at the University Farm by the same variety and since one strain of Early Ohio had held up for 8 or 10 years, it was thought strains might be selected which would be resistant to degeneration.

A. R. Kohler, my predecessor, however, had concluded that hill selection was of no value, but since he had made no attempt to study

*The data used in this paper were furnished by the Minnesota Agricultural Experiment Station through the courtesy of Prof. W. H. Alderman, Chief of the Division of Horticulture.

the performance of individual hills, a more intensive selection was considered worthy of trial.

In order to hasten the work, hill selections were made in 1913 in Early Ohio and Sir Walter Raleigh varieties, rather than commencing in 1914 with tuber-unit selections. The tuber-unit method might have been more scientific but it would have required an additional year to obtain results. About 100 hills of each variety covering variations in yield and shape, etc. were selected. During the winter, each lot was carefully gone over, the hills being weighed and the tubers described as to size, shape, depth of eyes, second growths, diseases and other abnormalities. These various characters were particularly noted since certain investigators had correlated them with degeneracy. At planting time each lot was planted as a unit, the rows being laid out 3 feet apart and the seed pieces dropped 18 inches apart in the rows. Checks were planted at intervals and on all sides of the field every precaution was taken to make the conditions uniform. Each seed piece planted weighed 1 ounce, the very small tubers being discarded and the larger ones cut to ounce pieces. If a tuber could not be divided into ounce pieces, a portion of the tuber was discarded. Seed pieces showing internal brown ring discolorations were planted and I might add that very few of such seed pieces produced plants showing evidence of the wilt disease.

In cutting the large tubers, the first seed piece was taken diagonally off the stem end and the other pieces were removed consecutively until the seed end weighing 2 ounces was reached. This seed-end piece was bisected, thus dividing the numerous buds. Where tubers weighed only 2 ounces they were simply split longitudinally. Since the pieces were planted in the same order as cut, the position of each hill indicated approximately from what part of the tuber the hill was derived and the number of seed pieces gave the approximate weight of each tuber.

During the growing season notes were made on the time of sprouting, vigor and size of plants. Wide variation was found to occur in 1914 in the size and vigor of the plants. In certain cases the progeny derived from one hill would be all strong and vigorous while in others a few plants might be strong and the others weak or medium vigorous. In tracing the weak or strong plants back to particular tubers, it was usually found that the progeny from one tuber was uniform, yet a strong vigorous plant and several weak ones might come from a certain tuber, or only one weak plant might appear among several strong ones. The data obtained from the thousands of hills are too extensive to publish, but the results obtained from a few typical hills of the Early Ohio and their progeny are given in Table I.

If, for instance, we follow out the results obtained from hill No. 75 of the Early Ohio, we will note that in 1913 it produced eleven tubers weighing 2.6 pounds. All of these tubers were planted in 1914. The first 3 tubers weighed approximately 1 ounce each and they produced plants No. 2534, 2535 and 2536 which yielded respectively 2.25, 1.9 and 0.85 pounds. The fourth and fifth tubers weighed 3 ounces each and their progeny in the case of the former varied in

TABLE I.—Performance of Selected Early Ohio Halls

1913			1914			1915			1915			1915			1915		
Hill No.	Yield in lbs.	No. of Tubers	Tuber	Hill No.	Yield in lbs.	No. of Tubers	Yield in pound	Hill No.	Yield in Pounds	Hill No.	Yield in lbs.	Hill No.	Yield in lbs.	Hill No.	Yield in lbs.	Hill No.	Yield in lbs.
46	.45	2	1	2189	.75	8	2189-1-1	1	.025	2189-3-5	5	2190-1-2	.005	2190-4-6	450	2191-2-4	400
			2	2190	.60	7	2189-1-2	2	.050	2189-4-6	7	2190-1-1	.005	2191-1-2	.050	2191-2-5	200
			2	2191	.65	7	2189-2-3	3	.050	2189-5-7	7	2190-2-4	.500	2191-1-3	400	2191-3-6	180
47	.55	2	1	2192	.45	5	2189-2-4	4	.250	2190-1-1	1	2190-3-5	.005	2191-1-3	.250	2191-4-7	100
			2	2193	.40	4	2192-1-1	1	.005	2192-2-5	5	2193-1-3	.005	2194-1-2	100	2194-2-5	100
			2	2194	.60	12	2192-1-2	2	.005	2192-2-6	6	2193-1-3	.005	2194-1-2	100	2194-3-6	100
							2192-1-3	3	.005	2192-2-7	7	2193-2-4	.350	2194-1-3	100	2194-4-7	100
75	2.6	11	1	2534	2.25	5	2192-1-4	4	.005	2193-1-1	1	2193-3-5	.400	2194-2-4	400	2194-3-7	100
			2	2535	1.90	18	2534-1-1	1	...	2554-2-6	6	2556-1-5	...	2561-1-2	...	2564-1-6	.015
			3	2536	0.85	11	2534-1-2	2	...	2554-3-8	8	2556-1-7	...	2561-1-4	...	2564-1-7	.015
			4	2537	1.60	12	2534-1-3	3	...	2554-3-9	9	2556-2-8	...	2561-1-5	...	2564-1-8	100
			4	2538	2.00	7	2534-1-4	4	...	2554-3-10	10	2556-2-9	...	2561-1-6	...	2564-2-10	100
			4	2539	0.60	7	2534-1-5	5	...	2554-4-11	11	2556-2-10	...	2561-2-7	...	2564-2-11	100
			5	2540	0.40	2	2534-1-6	6	...	2554-4-12	12	2556-2-11	...	2561-2-8	...	2564-2-12	150
			5	2541	0.70	6	2534-1-7	7	...	2554-5-13	13	2556-2-12	...	2561-2-9	...	2564-2-13	.050
			5	2542	0.50	6	2534-1-8	8	...	2554-5-14	14	2556-3-13	...	2561-3-10	...	2564-2-14	.015
			6	2543	0.45	4	2534-1-9	9	...	2555-1-1	1	2556-3-14	...	2561-3-11	...	2564-2-15	.050
			6	2544	0.50	4	2534-2-10	10	...	2555-1-2	2	2556-3-15	...	2561-3-12	...	2564-2-16	.250
			6	2545	0.55	7	2534-2-11	11	...	2555-1-3	3	2556-3-16	...	2561-4-13	...	2564-3-17	100
			6	2546	0.40	4	2534-2-13	13	...	2555-1-4	4	2556-4-17	.002	2561-4-14	...	2564-3-18	100
			7	2547	0.80	6	2534-2-14	14	...	2555-1-5	5	2556-4-18	.005	2561-4-15	.003	2564-3-19	.150
			7	2548	0.80	6	2534-2-15	15	...	2555-2-6	6	2556-5-19	...	2561-5-16	...	2564-3-20	.050
			7	2549	0.90	9	2534-2-16	16	...	2555-2-7	7	2556-5-20	...	2561-6-17	...	2564-4-21	.050
			7	2550	0.70	6	2534-2-17	17	...	2555-2-8	8	2556-5-21	...	2561-6-18	...	2564-4-22	125
			8	2551	0.90	10	2534-3-18	18	...	2555-2-9	9	2556-6-22	.500	2561-7-20	...	2564-4-23	.040
			8	2552	0.75	4	2534-3-19	19	...	2555-3-10	10	2556-6-23	...	2561-7-21	...	2564-4-24	180
			8	2553	0.55	5	2534-3-20	20	...	2555-3-11	11	2557-1-1	.050	2561-8-22	...	2564-5-25	125
			8	2554	1.20	6	2534-3-21	21	...	2555-3-12	12	2557-1-2	.100	2561-9-23	.015	2564-5-26	.050
			8	2555	1.55	8	2534-3-22	22	.003	2555-3-13	13	2557-1-3	.100	2561-10-24	.015	2564-5-27	150
			9	2556	1.75	9	2534-3-23	23	...	2555-4-14	14	2557-2-4	.055	2563-1-1	.400	2564-5-28	100
			9	2557	1.05	13	2534-3-24	24	...	2555-4-15	15	2557-2-5	.100	2563-2-2	.550	2564-5-28	100
			10	2558	1.50	10	2534-3-25	25	...	2555-4-16	16	2557-2-6	.100	2563-3-3	400	...	...
			10	2559	1.85	12	2534-4-26	26	...	2555-5-17	17	2557-3-7	.400	2563-4-4	400	...	...
			10	2560	0.70	11	2534-5-27	27	...	2555-5-18	18	2557-3-8	.200	2563-5-5	.150	...	...
			10	2561	2.80	14	2534-5-28	28	1.00	2555-6-19	19	2557-4-9	.050	2564-1-1	.025	...	...
			11	2562	0.55	10	2554-1-2	2	.050	2556-1-1	1	2557-4-10	.005	2564-1-2	.100	...	...
			11	2563	0.55	10	2554-1-3	3	.025	2556-1-2	2	2557-5-11	.050	2564-1-3	.100	...	...
			11	2564	2.15	7	2554-1-4	4	.050	2556-1-3	3	2557-5-12	.050	2564-1-4	.015	...	...
			11	2565	0.40	4	2554-1-4	4	.050	2556-1-4	4	...	...	...	...	...	...

productiveness from 0.6 to 2.0 pounds, and of the latter from 0.4 to 0.7 pounds. The sixth, seventh, and eighth tubers weighed 4 ounces each and with the exception of the last, the progeny of each was uniform. Number 10 produced 3 good hills and 1 weak one while 11 produced 3 weak hills and 1 strong one. Thus it is seen the parts of one tuber sometimes varied in their yielding potentiality. The results obtained this season were indeed satisfying. Certain units were vigorous and productive and the chances for securing good strains seemed to be excellent.

In 1915 the potato work was handled in a similar manner as in 1914, the hills being weighed, the tubers described, and representative hills selected for trial. To our surprise all the good, bad, and indifferent units produced few or not any tubers. In fact all lots had so degenerated that further selection work was considered impracticable. In Table I the results secured from a few of No. 75's and all of No. 46's and No. 47's progeny are given. With the exception of 1 tuber derived from hill 2554 which produced 2 plants with a yield of .55 to .75 pounds, all of the other tubers in this and other hills produced from not any tubers to a negligible quantity.

As oftentimes the low yielding hills selected in 1913 yielded as well as the higher yielding hills, my field assistant A. W. Aamodt, who had been assisting in the selection work, selected in 1915 the low and high yielding hills from 24 varieties during the time of harvest. Twenty-three of these varieties were new stock in 1914 at the University farm and consequently had not been grown long enough to give low yields. In 1916, 17 out of 23 varieties gave an increased yield in favor of the low-yielding hills. The very low yields in 1916 were partially due to the hot dry weather, but the climatic conditions should not have greatly affected the comparative results.

Thus the selection work conducted at the University Farm, St. Paul, proved to be a total failure. High and low yielding hills and tubers possessing so called desirable and undesirable characteristics followed the same trail. In fact, the low yielding hills oftentimes gave the best results.

It is obvious that selection under the conditions described is beyond the realm of genetics for such marked variations within varieties would not occur so rapidly under normal conditions. Some of you may state that the great variability was due entirely to the mosaic, leaf-roll, and other similar diseases. Undoubtedly, diseases have been a factor, but at the time of the experiment the trouble was diagnosed by leading pathologists as largely physiological, very little leaf-roll being noted. This selection work brings up many questions in degeneracy that lie beyond the province of this paper. It might be added, however, that other lots of potatoes during these years were apparently rejuvenated by a year's vacation in the northern part of the state. Were the organisms that caused this general debilitation lost by the change, or were they not transferred to the new tubers? One fact that is certain is that the yield of potatoes may be largely determined by the condition of the seed piece which goes into the ground and unfortunately, an inferior tuber can not be detected by inspection and oftentimes not even by the inspection of the mother plant.

TABLE II

Yield of Potatoes Produced by Low-Yielding Hills and High-Yielding Hills

Variety	1914 Bushels per Acre	1915 Bushels per Acre	1916 Low yielding hills selected in 1915 Bushels per Acre	1916 High yielding hills selected in 1915 Bushels per Acre	Increases of low- yielding over high- yielding Bushels
Early Petoskey	247.59	204.42	11.36	8.98	2.38
Early Eureka	192.72	195.25	12.60	4.21	8.39
Early Bird	215.28	101.75	15.64	14.48	.16
Early White Rose	233.58	136.13	17.98	13.20	4.78
Early Vermont	241.51	225.96	8.25	11.36	-3.11
Ohio Junior	207.17	203.40	39.96	28.23	11.73
Bovee	234.19	202.58	11.46	15.95	-4.49
White Star	136.58	100.38	.69	.36	.33
Burbank Russett	206.71	66.92	4.53	9.43	-3.90
California Russett	187.46	123.75	8.58	6.23	2.35
Uncle Sam	286.46	226.42	1.76	13.20	-11.44
World Wonder	168.67	88.00	17.80	20.90	-3.10
Green Mountain	165.46	78.38	9.71	5.13	4.58
Vermont Gold Coin	203.37	48.58	26.30	21.81	4.49
Norcross	201.21	84.33	14.48	.36	14.12
Happy Medium	217.51	165.00	29.94	12.46	17.48
Satisfaction	178.73	245.21	7.70	2.93	4.77
British Queen	208.54	401.50	7.33	4.95	2.38
Up-to-Date	201.51	213.58	.73	2.56	-1.83
Carman No. 3	192.96	124.21	28.80	11.91	17.89
Peerless Jr	211.75	225.75	28.05	23.43	4.62
Sir Walter Raleigh	172.33	121.00	37.76	18.88	18.88
Minnesota No. 2		268.13	154.55	83.96	70.69
President Roosevelt	274.08	109.54	*10.63	11.36	

*Grade No. 2 not included.

Thinning as a Possible Substitute for Seed Pieces of Uniform Size in Potato Tests

By O. B. WHIPPLE, *Montana Experiment Station, Bozeman, Montana*

FOR some years this station has been conducting thinning experiments with potatoes for the purpose of determining the commercial value of such a practice. A preliminary report upon this work has been published in bulletin form, and more recent investigations have tallied very closely with this earlier data. When summarized from a commercial viewpoint, we may say that thinning hills to a single stem improves the quality of the tubers both in size and uniformity in size. Under non-irrigated culture thinning usually increases the yield of marketable tubers. Under irrigated conditions thinning usually reduces the yield of marketable tubers unless the hills are planted closer than 12 inches apart in the row. But even

under irrigated conditions close planting with thinning produces a much more desirable crop than wider spacing without thinning.

More recently in our extensive hill and tuber line tests,—work in which we have used small plots,—we have practised thinning as a means of eliminating errors which might result from variation in number of stems produced in hills, and consequently a variation in the number of plants in plots. In these plots uniform-sized seed pieces have been planted. Recent investigations of Stuart¹ and earlier work of Aicher² and Welch³, as well as our own tests, have shown that the number of stems produced in potato hills is correlated more or less closely with the size of seed piece. These results suggest that variations in yields resulting from planting large and small seed pieces may be purely a matter of stand. Up to a certain point large seed pieces may increase the yield simply because hills with three stems, we will say, produce a greater number and weight of marketable tubers than hills with two stems. If this is true, the fertility of the soil, the moisture supply, and the distance between hills, will all be factors in determining the maximum size of seed piece which will be profitable to plant. Naturally, with low soil fertility, low moisture supply and close planting, we could not expect the same gains to follow planting large seed pieces as if the soil were fertile, the moisture supply adequate and the hills farther apart. This puts rather a new interpretation upon the advantages of planting large seed pieces, one of stand rather than one of great vigor of plants resulting from the use of seed pieces containing a larger supply of food material.

We have always appreciated that size of seed piece was a factor which must be considered in potato work. On the other hand, cutting seed pieces of uniform size is a difficult and tedious task. We have previously reported having devised a special knife for this purpose, but while it cuts pieces of uniform size, some may object to using seed pieces weighing only one-third of an ounce. In our own work we have found this seed piece very easily handled and none too small for excellent results. Tests which have a bearing upon this question were outlined at this station in the spring of 1919. The work was undertaken primarily to determine the value of thinning as a substitute for uniformity in size of seed piece. The seed used in these tests was from hill line selections of Russet Burbank, all grown under uniform field conditions in 1918. The plots were located on newly-broken clover sod and received ample irrigation. The small seed pieces were cut with our special cutter and for the most part contained one eye only. The large seed pieces were cut with a knife and contained one or more eyes. These were cut as nearly uniform in size as possible by eye and the weight was computed by dividing the weight of the lot of cut seed by the number of seed pieces in the lot. The seed pieces were dropped 12 inches apart in the row with an Iron Age planter and were covered to a uniform

¹Wm. Stuart, *Proceedings of the American Society for Horticultural Science*, 1917, page 39.

²L. C. Aicher, *Journal of the American Society of Agronomy*, Vol. 9, p. 217.

³John S. Welch, *Journal of the American Society of Agronomy*, Vol. 9, p. 224.

depth of three inches. The plots were single rows containing approximately one-thirtieth of an acre, those planted with large and small seed pieces alternating in the field. As soon as the plants were large enough to pull, all plots were thinned to single-stemmed hills.

Four plots planted with seed pieces averaging 1.04 ounces in weight gave an average yield of 20,575 pounds of marketable tubers per acre. Four companion plots planted with seed pieces weighing one-third of an ounce yielded 19,447 pounds per acre. This gives a difference of 1,128 pounds per acre in favor of the larger seed pieces. Five plots planted with seed pieces weighing 1.3 ounces gave an average yield of 17,867 pounds and the five companion plots planted with one-third ounce pieces 16,097 pounds of marketable tubers per acre. This gives a difference of 1,780 pounds per acre in favor of the larger seed pieces. These variations in yield are not very marked considering that in one case the large seed pieces were approximately three times as heavy, and in the other four times as heavy as the smaller pieces. Field counts before thinning showed that plots planted with 1.3 ounce seed pieces averaged 2.27, plots planted with 1.04 ounce pieces 2.22, and those planted with one-third ounce pieces 1.47 stems per hill.

These results show that variations in yield following the planting of large and small seed pieces must be largely a matter of stand, or, in other words, the number of plants produced per seed piece planted. On the other hand, the data do not show that thinning will entirely eliminate errors due to variation in size of seed piece, especially where the variation is so wide. We do believe, however, that within narrower limits, thinning will serve very well as a check upon variation in size of seed piece and may prove a valuable help in experimental tests with potatoes. This material is presented more for the purpose of calling attention to the possibilities of further work along this line rather than with the idea of drawing conclusions from the limited data we have accumulated. It is quite evident that we do need to improve our methods in experimental work with potatoes and in our own work this factor of variation in size of seed piece has been a difficult one to eliminate.

Correlation Between Depth of Eyes and Degeneration Among Potatoes

By O. B. WHIPPLE, *Montana Experiment Station, Bozeman, Montana.*

IN OUR studies of methods of potato seed improvement, extensive observations have been made upon types of potato plants frequently spoken of as degenerates. Possibly we are taking some liberties, if, in the light of present-day information, we consider spindle-sprout, mosaic, curly-dwarf and leaf-roll types of degeneration. But for the purpose of this discussion such a classification may, we think, be tolerated, even though considered by some as somewhat out of date. So far as the present paper is concerned

we shall refer only to mosaic and curly-dwarf types. Under local climatic conditions we have not always been able to distinguish between mosaic and curly-dwarf plants as they grow in the field. Many of our observations lead us to believe that there may be no real difference. Possibly we have not observed both in the field, but our supposed mosaic types have performed very much like others which we have considered typical curly-dwarfs. These types, as we have studied them, are both found to pass through intermediate stages. Both apparently exhibit the same crinkling of the leaves. Under local conditions these weak plants show yellowing in certain varieties, and in others they do not. In any case the result is the same, a loss in vigor and a corresponding loss in yielding power.

In our potato work we have had opportunity to study many of the standard varieties, several of which are notorious for degenerate tendencies. Thousands of tuber unit groups have been grown and have afforded opportunities for study of groups of hills in varying stages of degeneration. The varieties that have furnished most degenerate material for study are Early Triumph, Irish Cobbler, Green Mountain, Perfect Peachblow, Pearl, Rural New Yorker and Howard Elliot. The last-named is evidently the old variety White Elephant grown under a new local name. It was with this last variety that we first became suspicious of a correlation between depth of eyes and degeneration. As first grown the variety was a very vigorous type of high yielding power, but the eyes were too deep for a good commercial potato. On account of high yields it was decided to continue the variety and make an effort to improve its commercial value by selecting to a shallower-eyed type. Under such a system of selection the variety rapidly fell off in yielding power and the per cent of degenerate plants increased. In 1918, after three years of such selection, careful field counts showed 90 per cent of the plants with degenerate tendencies. This experience leads us to suspect that much of our difficulty in maintaining high-yielding strains of Early Triumph, Irish Cobbler, Green Mountain and Perfect Peachblow, resulted from over-zealousness on our part in selecting seed tubers for shallow eyes. During the season of 1919, seed plots of these varieties planted on the tuber-unit plan were carefully gone over and the different groups of hills marked as normal—vigorous intermediate and degenerate types. In some cases the differentiation was carried even farther and types between the normal-vigorous and degenerates were classified as intermediate and advanced intermediate types, and those with degenerate tendencies. The groups were classified on vine characteristics, the vigor of the plants and the color and crinkling of the foliage being the points noted. Later in the season these groups of hills were dug and the tuber characteristics noted. These studies show very conclusively that shallowness of eyes is correlated with degeneration. In practically all varieties the most perfect tubers so far as size, form and depth of eyes were concerned came from intermediate plants. In advanced degenerate types the depression about the eye is often entirely absent. The eyebrow is also less prominent in degenerate types.

To us this information came as a shock for we have often preached the doctrine of selecting shallow-eyed seed tubers. We have believed in it and we spread the gospel with considerable feeling. But we are now convinced that there is no surer way of bringing about deterioration within those varieties inclined to degeneration than by continued selection of shallow-eyed types. In all potato seed selection based on tuber characteristics alone, shallow-eyed tubers,—more especially in medium and small sizes,—should be looked upon with suspicion. Variation in depth of eyes is most noticeable in those varieties producing deep-eyed tubers normally, like Early Triumph, Irish Cobbler, Pearl and Green Mountain. But even in shallow-eyed varieties like Russet Burbank and Rural New Yorker, variation in depth of eyes is quite noticeable between lots of tubers from degenerate and normal-vigorous plants.

Varietal Variations as Seen in Similar Methods of Training Tomatoes

By GEO. W. HOOD, *University of Nebraska, Lincoln, Nebraska*

WE HAVE heard a great deal about the pruning and training of tomatoes. We have been told that pruning and training hastens the maturity of the crop and that better fruit is the result. Perhaps this is all true, and perhaps there is a place for the pruned and trained tomato plant, but just where it is remains a puzzling question. Without doubt forced tomatoes should be pruned and trained, but to me it seems an open question as to the advisability of practicing these methods in the open ground except in special instances where short seasons demand this practice.

The following tables will serve to give some data on the relative yields and the time of ripening for three of the leading varieties. It would seem according to the tables that certain varieties do best when grown under one method while another variety prefers a different method. The records here given are the average of fifteen plants and by careful examination of the results, many interesting things can be found.

There appeared to be only a slight difference in the yield of the Earliana when grown under the several methods but a wide range in the Stone and June Pink, ranging from 12.5 to 25.2 pounds in the June Pink and from 15.9 to 23.9 pounds in the Stone. The Earliana showed very slight gains and stood around 16 pounds for all methods and ranged from 14.3 to 19.5 pounds which is considerably less than either of the other varieties. With the Earliana and June Pink the greatest yields were obtained when the plants were not pruned, but allowed to grow naturally, but in the case of the Stone there seemed to be very little difference between the methods except when the plant was staked and pruned to one stem, and there a difference was noted which of course should be expected.

*Training Record—Stone**(Fifteen plants)*

Date Fruit was Picked	Staked and Pruned	Staked and not Pruned	Pruned and not Staked	Neither Staked nor Pruned
	Pounds	Pounds	Pounds	Pounds
Aug. 10	1.0	.....	.....	.....
Aug. 13	5.1	.....	1.8	1.8
Aug. 17	4.0	1.3	2.5	.....
Aug. 20	5.0	5.9	4.2	.....
Aug. 22	8.5	2.8	6.1	8.2
Aug. 27	10.8	4.3	9.0	11.5
Aug. 29	12.0	8.5	19.8	13.9
Sept. 1	22.6	11.1	14.7	26.6
Sept. 6	24.2	83.8	29.0	104.8
Sept. 12	8.6	32.4	14.6	16.5
Sept. 18	16.0	67.3	38.4	46.6
Total ripe Sept. 23 ..	117.8	217.4	140.1	229.9
Total green Sept. 25	117.0	111.7	193.5	129.7
Sum total	234.8	329.1	333.6	359.6
Average per plant ripe fruit	7.8	14.5	9.3	15.3
Average per plant green fruit	7.8	7.4	12.9	8.6
Total average ..	15.6	21.9	22.2	23.9

Still another interesting thing was seen in the total amount of ripe and green fruit secured from the different methods. The Earliana and Stone produced more ripe fruit when the plants were staked and pruned to one stem, when they were staked and not pruned, and when they were neither staked nor pruned, while the June Pink produced less fruit on the staked and pruned to one stem and more for the other three methods.

Contrary to the belief of many people the plants that were allowed to grow at will produced less green fruit at the end of the season than did the plants treated by the other methods, with the possible exception of the Stone which was about the same in the three cases, and judging from these results it would seem that the tomato plant will do better and produce more ripe fruit when allowed to grow at will and in its natural state rather than to handle it and attempt to compel it to conform to any set method of growth.

The earliness as indicated by the dates I hardly think compensates for the time and energy spent, to say nothing of the reduced yield over the other method.

Training Record—June Pink
(Fifteen plants)

Date Fruit was Picked	Staked and Pruned	Staked and not Pruned	Pruned and not Staked	Neither Staked nor Pruned
	Pounds	Pounds	Pounds	Pounds
Aug. 10	5.1	8.3	3.5	5.1
Aug. 17	7.4	9.6	5.8	10.1
Aug. 20	4.7	15.2	11.2	2.5
Aug. 22	4.3	8.1	7.0	13.6
Aug. 27	14.4	11.4	12.5	34.1
Aug. 29	8.3	12.5	17.5	28.8
Sept. 1	8.9	27.7	6.2	40.9
Sept. 6	16.5	97.0	22.9	109.0
Sept. 12	2.5	86.2	9.4	31.3
Sept. 18	21.4	50.8	43.9	58.2
Total ripe Sept. 23 ..	83.5	326.8	139.9	333.6
Total green Sept. 25 ..	105.8	103.8	96.0	45.0
Sum total	189.3	403.6	235.9	378.6
Average ripe fruit ..	5.5	21.7	9.5	22.2
Average green fruit ..	7.0	6.9	6.4	3.0
Total average	12.5	28.6	15.7	25.2

Training Record—Earliana
(Fifteen plants)

Date Fruit was Picked	Staked and Pruned	Staked and not Pruned	Pruned and not Staked	Neither Staked nor Pruned
	Pounds	Pounds	Pounds	Pounds
Aug. 10	3.6	.....	.....	.....
Aug. 13	4.1	.....	2.4	1.1
Aug. 17 .....	.....	1.0	2.6	1.5
Aug. 20	8.5	6.6	4.6	.....
Aug. 22	10.2	4.0	6.9	6.2
Aug. 27	11.4	7.0	6.8	19.1
Aug. 29	10.8	9.1	13.9	22.5
Sept. 1	11.2	8.4	9.1	19.0
Sept. 6	21.5	71.2	22.6	75.0
Sept. 12	13.5	30.0	11.1	17.6
Sept. 18	26.8	57.5	32.6	49.4
Total ripe Sept. 23 ..	121.6	194.8	112.6	211.4
Total green Sept. 25 ..	93.5	99.5	150.7	41.1
Sum total	215.1	294.3	263.3	252.5
Average ripe fruit ..	8.0	12.9	7.5	14.0
Average green fruit ..	6.2	6.6	10.0	2.7
Total average	14.3	19.5	17.5	16.7

Keeping Qualities of Hubbard Squash

By G. W. HOOD, *University of Nebraska, Lincoln, Nebraska*

UNCERTAINTY surrounds the marketing period of many of our horticultural crops. Just what is the proper time to market a crop is often difficult of solution. This, however, is simplified if we know something about the keeping qualities of the crop in question and the average price it will bring at different seasons of the year. Of course the price fluctuates from year to year and is relatively high or low at irregular intervals, but as a rule the longer a crop is held during the season, presumably the better price it will bring.

The first question then is to learn as near as possible the amount of shrinkage a crop undergoes, as well as the total loss occasioned by storing.

Having grown the Hubbard squash commercially for the past four or five years, I decided to ascertain if possible the amount of loss and shrinkage occasioned by storing and attempt to arrive at some definite conclusion as to the most profitable time to market this crop. The work was undertaken and I selected fourteen medium sized squashes from the lot and numbered each from one to fourteen. These were weighed accurately and stored in a cool airy room, the temperature averaging around 40 to 50 degrees F. The squashes were weighed every Monday morning and the records carefully kept for a period of five months, beginning the first of November and ending the last of March. The experiment was duplicated the following year and the results here given are the averages for the two years.

TABLE I

Specimen Number	Two Years Average Weight at Beginning	Two Years Average Weight at End	Average Loss	Average Loss Per cent.
	Pounds—Ounces	Pounds—Ounces	Pounds—Ounces	
1	7-8	6-4	1-4	16.6
2	7-12	6-8	1-4	16.1
3	6-0	4-11	1-5	21.7
4	10-2	8-0	2-2	21.9
5	13-4	10-9	2-11	20.1
6	10-8	8-10	1-14	17.8
7	7-8	5-4	2-4	29.9
8	8-8	7-0	1-8	17.5
9	7-8	4-8	3-0	39.9
10	7-12	5-7	2-5	29.8
11	7-12	5-12	2-0	25.8
12	9-4	8-0	1-4	13.5
13	14-0	12-10	1-6	9.7
14	12-6	10-14	1-8	12.1

Of course you realize that the figures here given cannot be regarded as conclusive proof of the keeping qualities but will give some idea as to the shrinkage due to storage.

TABLE II
Percentage of Monthly Loss

Specimen Number	1	2	3	4	5	6	7	8	9	10	11	12	13	14	Average
November	4.9	3.0	4.1	3.3	3.7	2.9	3.3	2.9	5.8	4.0	5.6	3.3	2.6	3.5	3.7
December	0.0	0.83	0.0	1.9	1.4	0.6	1.7	1.6	2.6	0.8	1.7	2.0	1.8	2.0	1.35
January	2.6	2.5	3.2	4.5	2.9	3.7	5.3	6.2	4.6	6.8	0.6	4.2	5.5	2.6	4.44
February	7.3	2.6	5.6	3.4	5.1	3.2	4.7	5.8	6.9	4.6	3.7	3.7	rotten	1.6	4.18
March	rotten	6.3	8.5	5.8	8.6	4.8	15.8	rotten	21.6	13.0	8.0	rotten	rotten	2.7	9.51

If the table is analyzed you will note that an average of 20 per cent loss in weight was occasioned during the storing period through shrinkage or loss of moisture. The loss from individuals varied greatly, due probably to the different degrees of ripeness and ranged from as low as 9 per cent to as high as 40 per cent with the majority ranging around 16 to 20 per cent.

A peculiar thing was observed in the time of the greatest loss, and one would naturally suppose this would take place soon after storage, but as seen from Table II that the average of the first two months was about half as great as the third and fourth months and only about one-fourth as great as the fifth month.

The question now arises as to what time is the most profitable to market, and in order to arrive at a logical conclusion I am taking the selling prices that exist on the Nebraska market and which have remained practically stationary for the past four years, increasing only slightly this past fall.

The beginning price paid for Hubbard squash is \$20.00 a ton which increases to about \$30.00 a ton around Thanksgiving and usually remains constant for the remainder of the season. Taking these figures as a basis, it will be found that by storing and holding the crop for two months, a profit of about \$17.00 a ton can be made for the trouble of handling. The question now remains whether the crop can be stored at a profit at these figures or whether more money will be cleared by hauling direct from the field to the market. Local factors will determine this as well as local prices and when the loss due to storage is known, the time for marketing can be figured out for each local case.

The Farm and Garden

By F. E. McCALL, *Agricultural College, Brookings, S. D.*

THE farm garden in South Dakota during the past four seasons has undergone many significant changes, many of which show real progress toward some definite improvement, while many others are still in the pioneer stage. Most farmers have been very insistent on growing standard varieties and acreages of grains in their fields but have made unprofitable experiment stations of their home gardens.

Previous to the war garden activities the farmer's garden was usually characterized by a decided lack of balance; that is, over production of certain perishable varieties, lack of small fruits, the absence of perennials, no succession of desirable varieties throughout the summer and insufficient quantities of vegetables for winter storage.

In the spring of 1916 an attempt was made to prove to the farmer that his garden could be of much greater value and become the chief source of food supply for the family if proper management were provided. Twelve farmers' wives were found who were willing to co-operate on the following schedule:

The owner agrees to carry out as many of the following provisions as may be agreed upon by himself and the horticultural specialist of State College:

1. To provide suitable area, location and preparation of the seed bed.
2. To secure seeds and garden plants as suggested.
3. Plant according to a definitely worked out plan.
4. To provide culture and pest control measures as may be directed by horticultural specialist.

5. To harvest crops at the proper time and tabulate yields.

The horticultural specialist will assist in,

1. Locating the garden.
2. Determining soil needs and type of culture.
3. Providing a workable planting plan.
4. Suggest as to planting and care.
5. Securing supplies, etc.
6. Furnish blanks for tabulations.
7. Keep in touch with the garden progress throughout the season.

These gardens were equally divided over the state, four of which were under irrigation, four under dry land and four under humid conditions.

Each of these twelve co-operators furnished data on their garden yields and values for the two years 1914 and 1915, the average results of which are in the following table.

The average results of the years 1916-1919 inclusive, are found in the latter part of this same table under the heading "During Demonstration."

BEFORE DEMONSTRATION

Type of Garden	Gross return per acre	Cost per acre	Net return per acre
Irrigation	\$75.00	\$17.00	\$58.00
Dry land	50.00	18.00	32.00
Humid	85.00	21.00	64.00
Average	\$70.00	\$18.66	\$51.33

DURING DEMONSTRATION

Irrigation	\$450.00	\$68.00	\$382.00
Dry Land	205.00	51.00	154.00
Humid	369.55	57.90	311.65
Average	\$341.51	\$58.76	\$282.55

The following plan with slight changes was used in all the demonstration gardens:

PLAN OF THE FARM GARDEN PLOT, ROWS RUNNING THE LONG WAY

Border space 4 feet

Red raspberries 100 feet; five trees each of Sapa and Opata plums 10 feet apart.

Space 4 feet

Currants, 12 bushes; Gooseberries, 12 bushes; Asparagus, 50 plants; Rhubarb, 25 plants.

Space 4 feet

Strawberries (matted row), $\frac{1}{2}$ early, $\frac{1}{2}$ everbearing.

Space $3\frac{1}{2}$ feet

Parsnips, 100 feet; Salsify, 100 feet.

Space $3\frac{1}{2}$ feet

Peppers, 25 feet; Parsley, 10 feet; Eggplant, 40 feet; Bush squash, 100 feet; Swiss chard, 25 feet.

Space $3\frac{1}{2}$ feet

Lettuce, 25 feet; Turnips, radishes, 25 feet; Icicle radishes, 25 feet; Onion sets, 25 feet; Beets, 50 feet; Spinach, 50 feet; (Navy beans for second crop).

Space $3\frac{1}{2}$ feet

Early cabbage, 50 feet; Cauliflower, 50 feet; Early peas, 100 feet; (Navy beans for second crop).

Space $3\frac{1}{2}$ feet

Tomatoes, 150 feet; Late peas, 50 feet.

Space $3\frac{1}{2}$ feet

Early corn, 100 feet; medium corn, 100 feet (followed by beets 50 feet, spinach 50 feet, rutabagas 50 feet and turnips 50 feet for second crop).

Space $3\frac{1}{2}$ feet

Late cabbage 200 feet.

Space $3\frac{1}{2}$ feet

Balance of garden to be planted in potatoes and late sweet corn with Hubbard squash in the corn.

The culture was the same for each garden in each district. In all cases the seed bed was fertilized and thoroughly prepared and the seeds and plants put in the ground at the proper time. Clean culture and succession cropping were practiced and a careful tabulation of results was made.

These demonstrations show that the man in charge, his selection of varieties and his system of management and culture are much more the controlling factors than the location and climatic conditions, and shows what every farmer can do if he follows a well balanced and well developed policy.

Nature of Hardening in Vegetable Plants

By J. T. ROSA, JR., *University of Missouri, Columbia, Missouri*

THE resistance of plants to cold, and the means of developing such resistance in cultivated plants has been an interesting problem for physiologists and horticulturists. The process of hardening vegetable plants grown in greenhouse or hotbed, before transplanting to the field, is an important step in the production of early vegetables. The means by which this hardening may be accomplished, and the nature of the changes which accompany the process in vegetable plants are the subjects of the present investigation.

The conventional method of hardening vegetable plants is to expose them to relatively low temperatures in a coldframe for ten days to two weeks before transplanting to the field. In work begun in 1917, several other methods have been utilized to check the growth of plants in the greenhouse. The final effects as to hardiness to cold are about the same as exposure to low temperatures in a coldframe. The methods used are: (1) Partial withholding of moisture for several weeks. (2) Growing plants in poor sandy soil. (3) Growing plants in poor soils and partial withholding of moisture combined. (4) Checking growth by allowing plants to become "root-bound" in small pots. (5) Applications of M/10 solutions of various salt solutions which inhibit growth. (6) Exposing greenhouse grown plants to relatively low temperatures in a coldframe. The effect of these treatments on the resistance of the plant to cold was determined by placing small groups of plants from each treatment in a cold chamber, held at the appropriate temperature for a definite length of time. The details of this part of the work will be reported later but it may be said here that in every case when the vegetative growth of the plant had been checked the plants were more hardy to cold.

The plants worked with chiefly have been tomatoes, leaf lettuce and cabbage. The first represents the group of plants considered more or less tender, and in which hardiness to cold cannot be developed to a very great extent. The other two represent the group of leafy vegetables in which hardiness can be developed to a relatively great degree.

The hardening process is accompanied by several easily observed morphological changes in the plant, the extent of these changes usually being proportional to the intensity of the hardening treatment. Color of leaf and stem in the case of both the tomatoes and cabbage change markedly. The green color of the stem becomes pink or even dark purple, probably due to accumulation of anthocyan, which often accompanies an increase of carbohydrates in plants. The leaves of the cabbage become a lighter green, and frequently show a considerable amount of pink coloration, especially around the margins. Tomato leaves also become lighter green, and in extreme cases yellowish-green. The under sides of tomato leaves may also become quite purple, especially the older leaves. All of these changes seem to be in accord with the fact that metabolic activities within the plant have been slowed up by the hardening treatment.

In case of cabbage, the development of the waxy leaf covering or "bloom" is much accentuated in hardened plants. This covering may be significant in relation to the plants' resistance to cold, for it may prevent particles of moisture, freezing on the surface, from inoculating the moisture of the tissues with growing ice crystals, thus permitting a greater degree of super-cooling of the interior of the leaf without ice formation.

The texture of leaves of hardened plants is tougher and more leathery than that of tender plants of the same age. Also the stems become more woody and firmer. The percentage of dry matter is generally greater in hardened plants, as indicated in Table I. Data

Plant	No.	Treatment	Date Plants were Gathered	Average Green Weight Grams	Average Dry Matter Percent	Remarks
Cabbage	A3	Minimum moisture	March 20, 1919	6.228	9.22	Uninjured at -4° C. for 2½ hours
	A1	Optimum moisture	" "	9.780	8.65	Killed at -4° C. for 1 hour
	C1	Grown in ½ sand, ½ loam, optimum moisture	March 20, 1919	5.619	7.57	13.45
	C2	Grown in loam, optimum moisture	" "	8.541	.937	10.97
	C3	Grown in ¼ manure, ¾ loam, optimum moisture	" "	13.247	1.087	8.20
	E1	In cold frame 20 days	March 20, 1919	7.300	.966	13.24
	E2	In cold frame 10 days	" "	7.925	.893	11.28
	E3	In greenhouse 15 days, 20° C.	" "	8.240	.837	10.17
	E3	In greenhouse 15 days, 20° C.	" "	8.240	.837	10.17
Leaf lettuce	A3	Minimum moisture	Oct. 31, 1919	1.290	.084	6.56
	A1	Optimum moisture	" "	2.229	.124	5.52
	B2	Grown in ½ sand, ½ loam, optimum moisture	Oct. 31, 1919	2.883	.148	5.13
	B3	Grown in ½ sand, ½ loam, optimum moisture	" "	3.630	.194	5.36
	B6	Grown in ¼ manure, ¾ loam, optimum moisture	" "	4.487	.199	5.32
	D1	Grown in coldframe	Oct. 31, 1919	1.367	.122	8.80
Leaf lettuce	D3	Grown in greenhouse	" "	2.229	.124	5.52
	A3	Minimum moisture	May 3, 1919	2.427	.399	16.45
	A2	Medium moisture	" "	7.811	.927	11.86
Tomato	A1	Excess moisture	" "	36.660	4.175	11.4
	B1	Grown in ½ sand, ½ loam, medium moisture		2.095	.354	16.90
	B2	Grown in ½ sand, ½ loam, medium moisture		2.448	.379	15.50
	B3	Grown in ½ sand, ½ loam, medium moisture		7.917	1.290	15.50
	B4	Grown in loam soil—medium moisture		10.149	1.409	13.88
	B6	Grown in ½ loam, ½ manure, medium moisture		32.546	3.878	11.90
	E3	In coldframe 15 days		14.482	2.027	14.0
	E5	In greenhouse		30.715	3.986	12.95
	E5	In greenhouse		30.715	3.986	12.95

presented here also indicate the marked difference in size of hardened and non-hardened plants as measured by the average green weights of the portions above ground from plants of the same age. This is in accord with the popular conception of hardy plants being somewhat smaller, more "stocky," and less "sappy" in appearance than tender or non-hardened plants.

It is seen from this table that there is a gradual decrease in the weight of plants as the checking treatment becomes more intense. The experimental results on freezing plants from these groups indicate that the hardness of the plant is in direct proportion to the intensity of the checking treatment.

It was suggested by Chandler that perhaps the cells in hardy plants were smaller than in tender plants. Some work has been done in our investigations here, to determine whether or not there are any significant changes in the cellular structure of leaves from hardy and non-hardy plants. Pieces of leaves were gathered from plants included in the various treatments described in Table I. These were killed in chrome-acetic acid, dehydrated in alcohol, imbedded in paraffin, sectioned and stained with safranin and Delafield's haematoalin. The thickness of leaves, the relative amounts of palisade and parenchyma tissue and the length and width of palisade cells were measured. From the latter, the cross-section area of the cells can be roughly computed. Table II gives the measurements for two sets of cabbage leaves.

TABLE II
Size of cells in hardy and non-hardy cabbage plants

No.	Treatment	Nature of Plant	Thickness of Leaf	Width of Palisade Cells	Length of Palisade Cells	Area of Palisade Cells
A.3	Grown with minimum moisture supply	Mu.	Mu.	Mu.	Mu.	Sq. Mu.
A.1	Grown with full water supply	Hardy	269	19.4	27.8	538.8
		Tender	291	19.1	36.3	694.0
E1.	In cold frame 15 days	Hardy	312	19.9	31.1	619.5
E3	In greenhouse	Tender	274	20.19	36.9	772.0

These data indicate a slight increase in size of palisade cells in the tender plants, both in case of the wet versus dry-grown plants, and the coldframe versus greenhouse plants. The thickness of leaves is greater in the case of the tender wet-grown plants than the hardy dry-grown plants, while the reverse is true of the hardy coldframe plants and the tender greenhouse plants.

The density of the sap as measured by the depression of its freezing point was considered of great importance by Chandler, in relation to hardness of plants to cold. He found that hardened plants quite consistently exhibited greater depression of the freezing point of the expressed juice. Since Chandler made numerous freezing point determinations here on more or less similar material, only a few determinations of this sort have been made with plants from

the various hardening treatments in the course of this work, which are presented in Table III.

TABLE III

Freezing point determinations on expressed juice of tomato and cabbage plants

Plant	No.	Date	Treatment of Plant	Depression of freezing point degrees C
Tomato (leaves only)	A3	Dec. 13, 1919	Minimum moisture	1.370 C.
Tomato (leaves only)	A1	Dec. 13, 1919	Optimum moisture	.820
Tomato (leaves only)	B2	Dec. 13, 1919	Grown in $\frac{1}{2}$ sand, $\frac{1}{2}$ loam, med. moist	1.180
Tomato (leaves only)	B4	Dec. 13, 1919	Grown in loam, med. moist	1.018
Tomato (leaves only)	B6	Dec. 13, 1919	Grown in $\frac{1}{2}$ manure, $\frac{1}{2}$ loam med. moisture	.950
Cabbage	A3	Nov. 22, 1919	Minimum moisture	1.083
	A1	Nov. 22, 1919	Optimum moisture	.785
Cabbage	D1	Nov. 22, 1919	Grown in coldframe	1.200
	E2	Nov. 22, 1919	In cold frame 5 days	.963
	D4	Nov. 22, 1919	Grown in greenhouse	.785
Cabbage	C1	Mar. 23, 1918	Grown in $\frac{1}{2}$ sand, $\frac{1}{2}$ loam	1.155
	C2	Mar. 23, 1918	Grown in loam	.750

It is seen here that the freezing point is somewhat lower in case of plants subjected to various checking treatments, which agrees with Chandler's work, and is in accordance with the greater percentage of dry matter in these plants, as well as the accumulation of sugars, to be mentioned later.

One of the striking differences between tender and hardy plants is the rate of growth. This has been measured week by week for tomato plants included in the various treatments mentioned in Table I. These data are presented graphically in charts 1, 2, and 3. Cabbage and lettuce also show similar differences in the rate of growth, but this is less easily measured because of the structure of these plants.

These charts indicate the slower rate of growth of tomato plants subjected to the various treatments which check growth, also the smaller size (height in m.m.) of the plants just before transplanting to the field.

Considerable attention has been given to the chemical changes in plants subjected to the hardening process. In fact, some investigators consider chemical changes in the protoplasm to be the principal means by which plants acquire resistance to cold. Most of our work so far on the carbohydrate changes in hardy and non-hardy plants, was produced by various treatments described in Table I. A detailed report of this work is to be given elsewhere. It may be said here that the changes in the carbohydrate composition of these plants vary in the same general direction, in the various treatments which have been used to check vegetable growth and which have been found to develop hardiness. In cabbage, the greatest change in the hardy plants is in the accumulation of sugars, but this accumulation

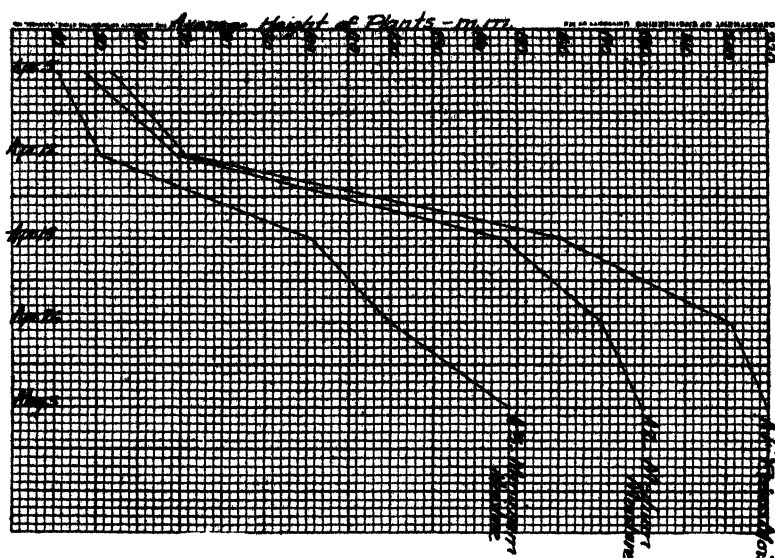


CHART 1—Effect of Moisture Supply on Rate of Growth of Tomato Plants

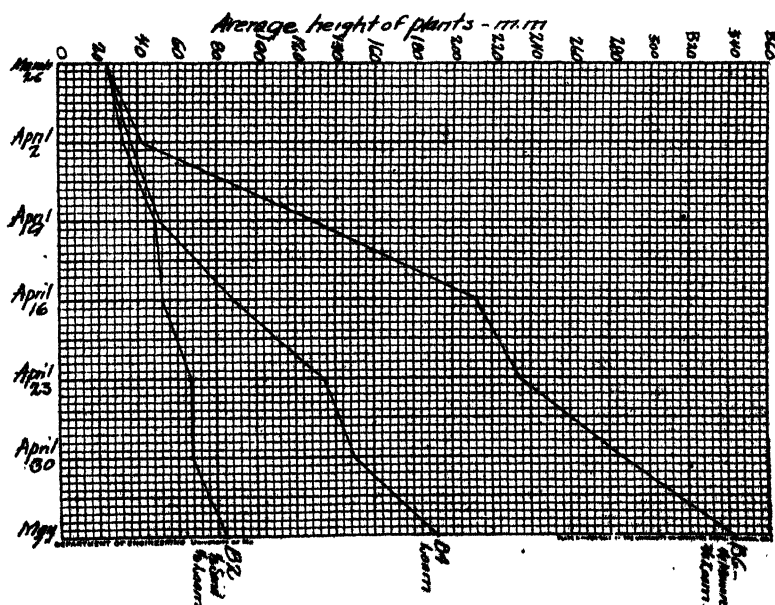


CHART 2—Effect of Soil Fertility on Rate of Growth of Tomato Plants

is much greater in plants exposed to low temperatures in the cold-frame, than in the plants hardened in the greenhouse by withholding water. There is also an increase in starch and total polysaccharides in hardened cabbage plants. In case of lettuce the same changes have been found as in cabbage. In case of tomato, the same type of change has been found, except that the increase of sugars in hardy plants is relatively slight, while the accumulations of starch is very much larger than in cabbage and lettuce. Since to sugar has

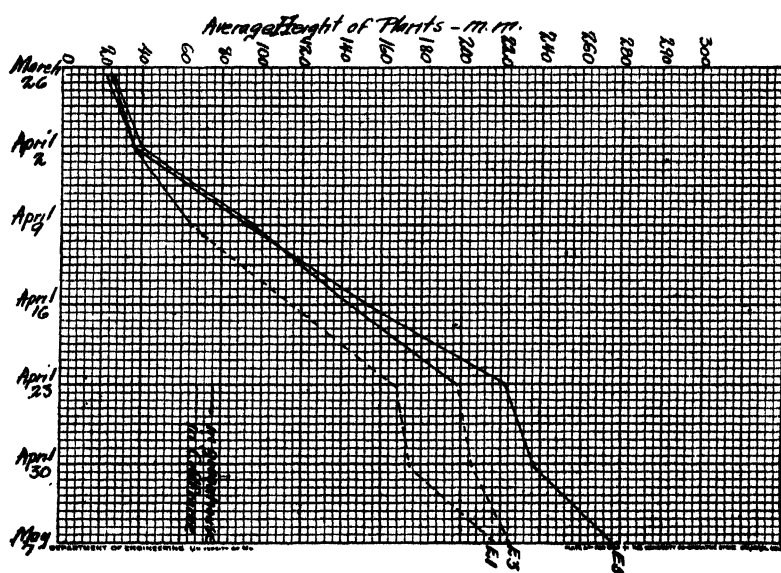


CHART 3—Effect of Exposure to Low Temperature in Cold Frame on Rate of Growth of Tomato Plants

been ascribed a protective action on colloids, such as plant protoplasm, it may be significant that there is little increase in sugars in hardened tomato plants, which can be brought to stand only a relatively slight degree of cold, while there is a much greater increase of sugar in plants which are susceptible of greater degree of hardening than the tomato. In connection with the carbohydrate accumulation in these hardened plants, it is interesting to note that Hartwell found a marked accumulation in plants in the field where growth had been checked by various causes.

SUMMARY

This investigation has indicated that hardness to cold may be developed or increased in cabbage, lettuce, and tomato plants by various treatments which check vegetative growth. The outstanding effect of these treatments upon the plant is slowing the rate of growth. Other changes have been found to accompany the checking process, as increase in percentage of dry matter, greater depression of

the freezing point of the sap and an accumulation of sugar, starch, and polysaccharides. In addition, it seems that there may be smaller cells in hardened plant tissues.

The fact that vegetable plants may be hardened by various checking treatments other than the conventional method of exposure to low temperatures may be of use to the practical horticulturist.

The Modification of Vegetable and Reproductive Functions Under Some Varying Conditions of Metabolism

By E. J. KRAUS, *University of Wisconsin, Madison, Wis.*

This paper will probably be printed in the *Annals of Botany*.

***The Impartiality of Research**

By L. H. BAILEY, *Ithaca, N. Y.*

THE speaker developed his subject mostly as an informal talk or discussion. It was divided into two general parts: A body of statements or precepts, and a number of direct applications to present botanical work. The speaker explained that he used the word botany in a very broad sense, covering the general subject of plant knowledge whether persons were known professionally as botanists, horticulturists, agronomists, or under other titles. He had in mind the direct study of plants in the scientific spirit, quite independently of the particular range or field in which any particular investigator may be interested. He indicated that the combined meeting of botanists and horticulturists was an occasion of great pride and one that gave much hope for the future in making for solidarity of interests and indispensable fellowships. The science of botany, in its broadest sense, will gain public recognition and support largely in proportion to the unanimity with which the subject is presented by those who are concerned in it.

I. THE PRECEPTS

It is a common saying with us that a person should be able to see both sides of a question. I think it is more important, however, that he should be able to see the middle of it.

*Abstract of address before joint meeting of the Botanical Society of America, the American Phytopathological Society, and this Society.

I mean that it is more important to you and to me, although perhaps not so entertaining, that a person should understand his subject than to be able to juggle a compromise between two opinions on it.

Habitually we approach our subjects sidewise. We investigate as democrat or republican, high churchman or low churchman, American or Englishman, Darwinian or Lamarckian, christian or Confucian. More than we know, our minds are made up before we begin. The old woman said she was going to find out before she punished John, and if she couldn't find out she would punish him anyway.

We seem to try to make peace with our subject before we attack it. We skirmish around it, and estimate the partisanship in the history of it. Learning the parties in it, we then determine which party we shall attack or with which we shall agree, being careful to agree when not sure of our ground and to differ when we can make reputation by the overthrow of an accepted opinion. We become contestants, engaged in polemics.

Practically all men and women are partisan. To be not partisan is thought to be colorless. Yet I cannot think of Darwin as colorless. Darwin did not answer his critics and argue with them, yet no man in the past century was so much misunderstood and abused. A few of the older ones of us have burning recollections of that mighty controversy, reaching every range of thoughtful men. Darwin was possessed of the idea that truth would win its way. His responsibility was to discover it, not to defend it. If he had partisanship, they did not color his studies of plants and animals. If he had been a disputant, his power would have been relatively small. Does he not remark, in one of his letters, that he was not able to make replies quickly to those who objected to his conclusions? Let us be thankful.

We live in a time when it is politic and proper to make accommodations. We think it necessary, in order that we may be at peace with our neighbor and society, to be "polite." But it is not necessary that we make accommodations in our science work. Because a man is a proper democrat, but condescends to live at peace with his republican neighbor, is no reason why he should try to make an arrangement with a chromosome.

Now, it is the chromosome that makes us free. It leads us out of previous arrangements, snaps the strings that tie us to old accommodations.

Habitually, then, we are partialists. Research in science is the antithesis. To render us impartial is the noblest contribution that science makes to human welfare.

To find the fact and to know the truth,—this is the purpose of the quest of science. If the truth can be applied to the arts of life, the gain is good; but the truth is valuable on its own account, and for the range and reach that it imparts to the mind. As the truth is of itself, as it knows no person and no condition, so is its application impartial and so is its effect on the mind uncompromising.

One never makes the quest with success unless the mind is open at the start. The quest is to find out, always to discover, never to prove a thesis or to demonstrate an assumed position. Herein does

this mind differ from that of the advocate who must merely prove a case, or from that of the preacher who must support a dogma, or from that of the politician who must defend a party.

If science is not dogmatic or partial, so is it not disputatious. A few weeks ago a great meeting was held to discuss a difficult public situation, involving disease. There were violent opinions and strong parties for and against. One man read a paper giving the facts, without argument. The facts, not the arguments or the heated debates, finally determined the procedure. No species of argument can influence a micro-organism.

So accustomed are we to partial opinions and to subjective "beliefs" that plain statements of facts may fail to hold our attention. They do not have sufficient color, or power of entertainment, to elicit applause, and we say that the reciter of them is impractical, which is the heaviest epithet that we can hurl at a man in a commercial epoch.

Never have we arrived at mastery and never do we discover the greatest intellectual delights until plain facts, ungarnished, standing for themselves, are poetry and painting and inspiration. Nothing is so beautiful or abides so long as the truth of facts; and keen is the joy when we partake in the discovery of them. To read with relish a clear statement of the plants that grow in a field, of the birds that breed in a wood, of the rocks that lie on a hillside, of the stars that stand in the heaven, is a rare and choice satisfaction and one that we love to share with every friend.

Science also is unselfish. To be selfish with the results of one's scientific labors is as much to be reprehended as to be selfish with time or money or counsel, and even more so. To act grudgingly with one's facts or discoveries, to hoard and withhold, to stand primarily for "credit," is not the science spirit.

In the truth there is no secrecy, no deals, no combinations, no conspiracy, no favor, no courtesy to high opinion. Whether there will be an eclipse does not depend on discussion nor even on agreements of any number of persons. Whether a species migrates in twos or in tens does not depend on what somebody "believes" or on authority. Yet we still accept the opinions of commissions rather than patiently and quietly to discover the facts. It is fundamental to our welfare that we distinguish sharply between facts and opinions.

Every discovery of new truth, however near or remote, is an example in intellectual poise. It is a contribution to self-mastery, a reason for independence. The greater the number of discoveries, the wider their range, the more widespread their publication, the greater will be the independent thinking of the people; and finally the intellectual attitude will express itself in political practice.

The science-spirit removes at once the fear of truth and the fear of dogma and the fear of nature. Ignorance is always bondage, and it is the truth that shall make you free. The old theologies have been founded on the fear of nature, and the release lies in propitiation.

II. THE APPLICATIONS

What is the purpose and what the value of our widespread teaching of science if not that its mental attitude is to be applied in all the horizons of life? If this attitude were applied in public affairs we

should forthwith have a new politics. The great gains in scientific research and in science-teaching lie in these mental postures rather than in the direct application to invention, production, commodities, and communication.

The stimulation of the research spirit lies at the root of democracy. It develops the merit of the individual, and this is a form of public service. A democracy is the expression of the attainment and merit of all its citizens.

I would not have you think that the science-spirit is the last stage in our intellectual evolution; some day the race will gain its highest conquests by free and plain intuition; but first we must see clearly and we must know. First must we be able to use the five senses. Only free and trained persons can be seers.

The responsibility for the stimulation of research lies with the teachers and investigators. It is not sufficient that we engage in research on our own account, but we must also live the significance of it in public view. As we investigate and as we express the results of our investigation, so will the people measure the value of the research spirit as a motive in life.

I mean to make several particular applications. I must not let you think that we have all yet learned what is implied in the impartiality of research. I would not care to speak on this subject to zoologists, physicists, or others, but I speak with some freedom to botanists and horticulturists because I have been asked to do so. I must also confess that I draw my applications largely from introspection. I am convinced that as botanists and horticulturists we are possessed of several precious partialities.

(1) We are likely to maintain the partiality of professional pride. If we are botanists, we desire to make sure that the piece of work is accomplished by a botanist; if we are horticulturists, we must be convinced that the investigator is a horticulturist. We may still have something of the old feeling of "our set." Yet I defy any one of you to make a definition that will separate botanists from horticulturists. The only test is really this: is it honest work?

Am I willing to be called by another name? If not, am I a scientist or am I a class-unionist?

(2) We are partial to our subject, to the extent that we must protect it. This is very different from liking the subject. We seem to feel that any admission of an adverse set of facts or philosophies is a criticism of the subject. Yet we are to remember that our great prophets have stated the exceptions and the objection. Who could be more cautious and more solicitous of the opinion of the reader than was Darwin in propounding his hypothesis of pangenesis?

Am I willing to accept adverse suggestions? If not, am I a scientist or am I a defender of the faith?

(3) We are likely to be partial in the sorting of evidence. We are to be cautious that we do not take the attitude of the advocate or the trial lawyer, assembling and remembering the acts that agree with our position and forgetting or slighting others. I recall a writer who quoted certain things from my own publications to sustain an hypothesis, but from the same publications he might have cited other facts in opposition to this hypothesis.

Am I willing to state the disproofs as well as the proofs, the negatives as well as the positives? If not, am I a scientist or am I an advocate?

(4) We may be partial to our own statements. I think we place far too much value on what is called consistency. Was it not Emerson who remarked that consistency is a trait of small minds? I wonder whether we are as willing to correct ourselves as to uphold ourselves, or to correct ourselves as to correct others. I am wondering whether we have developed the rare trait of looking objectively at our own work.

Am I willing to look at my work with the eyes of another person? If not, am I a scientist or an enthusiast?

(5) We become adherents to an hypothesis. We are known as Darwinians, neo-Darwinians, Lamarckians, neo-Lamarckians, Mendelians, rather than as scientists. We are expected always to uphold our particular cult. A Lamarckian seems to be precluded from being an anti-Lamarckian and perhaps even a Darwinian. We go to a man's lecture because we want to hear him uphold his clan.

All this often goes to ludicrous ends. All the exceptions to the hypothesis are absorbed into the hypothesis by redefining the hypothesis so that there are no exceptions to the hypothesis! Acquired characters are not heritable: if they are heritable, they are not acquired characters! Only mutations and not variations have effect on the phylum: if variations have effect on the phylum, then they are not variations but mutations! Eventually we pile so many ideas on the hypothesis that the original clarity is lost, and the whole structure falls by its own weight. Perhaps we are to have an illustration in Mendelism. If Gregor Mendel were to come back to us, he would be stumped by Mendelism. Without expressing my own opinion, you will allow me to quote from a recent statement on Mendelism by R. A. Rolfe, of the Royal Botanic Gardens at Kew, who is a standard authority on orchids and their hybrids and on other groups:

"There is a tendency among a section of biologists to regard everything from the Mendelian standpoint. We have the Mendelian theory, Mendelian principles, Mendelian laws, and even Mendelian evolution. Mendelism has become a sort of fetish, which is explained in a jargon that is largely unintelligible outside the circle of its devotees." After citing the work of Knight with peas in 1787 (published in 1799) and of Goss and Seton in 1822, he remarks that "neo-Mendelians might well return to this simplicity and directness of statement."

Am I ready to challenge my hypothesis in the face of contrary findings? If not, am I a scientist or am I an apologist?

(6) We are still obsessed of the partiality of tradition. We yet speak habitually of "pure science" and "applied science" as if they were realities. Science knows no impurity. Until we outgrow this old partiality, we are not scientists.

Since I am speaking to botanists and horticulturists, I recall again the whole subject of the state of systematic knowledge of cultivated plants. I think similar statements might be made in respect to such knowledge touching domesticated animals. I am botanizing in New York: I find a plant that puzzles me; I recognize it as a

Lactuca; I take it to my laboratory and consult the sheets of *Lactucas* until I make up my mind what it is; or if I do not have sufficient specimens, I borrow them of other botanists. I am traveling in Manchuria: I find a curious thickened stem in the market; on cutting it open I find a milky juice, and am puzzled to know what it may be; I get seeds and grow it; the plant turns out to be a *Lactuca*, allied to *L. sativa*; do I then consult herbarium specimens of *Lactuca sativa* and its various forms for the determination of my plant?; no, for there are no such specimens, yet my plant is a plant for all that; I merely go back into some old book or some compilation and try to identify my plant by an eighteenth century method.

We are studying our native flora by twentieth century methods, but in large part the common determination of cultivated plants is not yet a scientific exercise.

(The speaker expanded this part of his subject, citing examples and making several applications).

For our neglect of the cultivated flora, we excuse ourselves by many apologies and sophistries. Some of these may be briefly mentioned: (a) We say that cultivated plants are so variable as to be difficult of study. Suppose they are: shall we run because the problem is complex? But probably the statement itself is not true. In cultivated plants we are likely to save and name the variables. We are always looking for them. We give them a chance to develop. But there is nothing in the cultivated flora more inherently difficult so far as forms are concerned than *Hieracium* and *Crataegus*. The groups that are variable in cultivation are likely also to be variable in the wild if we were to look for the variations. I might cite only the *Chrysanthemums*, *Brassicacae*, *Pyruses*, *Rosas*. We see the variations in a house of carnations, but we do not see them in *Stellaria media* where they are much greater. When we bring a wild plant under cultivation, we behold it breaking up into variables, as witness *Capsella*, *Leucanthemum*, *Oenothera*. The excuse that cultivated plants are too variable for study is entirely unworthy. (b) We think that cultivated plants are endlessly hybridized. I think this is not true. I doubt whether there are more hybrids in cultivated *Rubus* than in wild *Rubus*. The same thing probably holds in many other groups. There are a few great hybrid groups in cultivated plants and there are similar groups in wild plants. We invoke hybridity as an excuse to cover our ignorance. (c) We think there are no good "characters" in cultivated plants. This is not true. We may have to take a different attitude toward characters in particular groups, but the characters are there if we look for them. A house of carnations still has all the essential marks of *Dianthus Caryophyllus*.

Am I willing to break with tradition? If not, am I a scientist or am I a dogmatist?

(7) We are partial to "records". We live in the epoch of records rather than of results. Records become our household gods. This is particularly true with all those subjects that are capable of more or less expression in figures and diagrams. We have become statisticians, as if merely to accumulate were the end of research.

Am I willing to abbreviate my records in the interest of a clear conclusion? If not, am I a scientist or am I an accountant?

(8) We are partial to our patronymics. We must identify our names with our work. It is important for us to know who did it, that we may have a clue as to how poor or how good it may be, and also to aid in making an index. But I am speaking of the attitude of mind, of the inclination of the man toward his work.

We cannot draw a better illustration than from the field of binomial nomenclature. This range of work is the most egotistic department in science, because a personal name goes with every plant-name as an appendix of it. We are making rules for the governance of nomenclature, but rules are of no value unless they are founded on agreement; and for every three persons that agree we may expect one who does not agree and the rules thereby become void and often mischievous. They do not work merely by majority. In the botanical field, the International rules have solidified the opposition. I am not arguing against rules of nomenclature, for I suppose we must have them although I wish we might have adopted the principle of developing agreements rather than making laws; but I wish to make the application to illustrate my point. If we were to take the man's name from the combination or formula that he makes, we would probably at once eliminate a good half of the new confusions in plant names. The names complicate the literature, multiply the difficulties of subsequent workers. I do not know how to take these names off. I suppose it cannot be done. I wish the Botanical Society of America would evolve a scheme. All rules allow the patronymics to be placed with the new combination, but this does not justify the practice. If there were some way whereby the combiner would not get the "credit" of his patronymic on new combinations, we would at once pull the teeth of many of our difficulties. I do not know who could practice this kind of dentistry, but it needs at all events to be undertaken.

Am I ready to make a transfer of binomials in *Equisetum* or *Rhododendron* or *Taraxacum* without attaching my name to it, in case the bibliographical method could be found by agreement? If not, am I a scientist or am I an egoist?

Research: The proper allegorical figure is not *Justitia*, blindfolded, balancing her scales. It is rather the marble of Darwin in on the great hall at South Kensington, sitting, all senses alert, thinking.

Report of the Committee on Research and Experimentation

During the past several years the Committee on Research and Experimentation has made reports in which the research spirit and attack have been outlined, some means of stimulating research generally and specifically expressed, and various possible research projects suggested. Since this work has been very well done it is doubtful if much would be gained from a further extension of the same type of discussion dealing with all or any considerable portion of those particular phases of research work. What really is needed now and for

the future, is some definite action or suggestion on the specific perplexities and problems which confront each worker in horticulture, and some means of aiding in a mutual exchange of ideas between investigators.

It would seem, therefore, either that the Committee can now be discontinued or given certain functions to perform. Should it seem desirable to continue the Committee with an idea that its members act in any consultatory capacity whatever, it should be definitely understood that they do so only upon the request of any member desirous of referring matters to them, there being no intention of superimposing such an organization upon the Society, or that it acts be regulatory or mandatory. Some specific suggestions as to the possible services such a Committee could render are as follows, others could be suggested:

1. To review new projects before submission to or approval by station or federal authorities.
2. To suggest methods, materials, sources of literature, or render other assistance in connection with any projected investigation.
3. To consult personally or otherwise, on work in progress.
4. To aid in the correlation of work between various experiment stations and investigators.
5. To read critically, or otherwise to make suggestions on articles for publication.

In order effectually to carry out such a program the personnel of the Committee should be increased to five members, instead of three, one or more representing each of the major lines of interest in horticulture.

Any such arrangement as proposed above can prove of benefit or be effective only when entered into with the fullest spirit of collaboration on the part of all concerned. It means that the members of the Committee must expect to give whole heartedly and freely of their time, best judgment, and advice to anyone desiring to make use of the same, and yet not become in any sense dogmatic or autocratic. It would be a great misfortune for this Society, or any other, to have set aside a group of its members who should constitute an authority, which should attempt to regulate the activities of the others. Such an arrangement would be a most direct and certain way of stifling individual initiative and thought, the most valuable of all assets in research work. On the other hand no committee can be effective unless those to whom it is expected to be of service voluntarily avail themselves of the opportunities offered and seriously consider such judgments as are sincerely rendered. Now whether there are men who are broad enough to serve on such a committee, men in whom horticultural workers have full confidence, men who can find sufficient time from their own labors really to aid others and who possess a spirit of interest in others sufficient to spend many hours in an attempt at bettering experimental horticulture, may be open to question.

The whole matter as to the possible continuance of the Committee on Research and Experimentation, and if continued what duties and functions it is supposed to perform, is one which very properly comes squarely before the Society for consideration and decision at the present time.

Items of Business

ELECTION OF OFFICERS

The nominating committee made its report and officers and committees as listed on page 5 were elected.

SECTIONAL MEETINGS NOT DESIRED

It was unanimously voted that we do not attempt to break up into sections in the future, but to have the entire program given at the general sessions.

ABSTRACTS OF PAPERS FOR PROGRAM COMMITTEE

Since there is not always time to read and discuss all of the papers, it is requested that abstracts of all papers be furnished to the chairman of the program committee. In case of necessity the abstracts only will be presented at the meeting, but the entire addresses will be printed in the report.

WHEN QUALIFICATIONS FOR MEMBERSHIP ARE DOUBTFUL

In case the Secretary has reason to doubt the qualifications of membership of an applicant, he may refer the matter to the Executive Committee for final action.

COMMITTEE ON RESEARCH AND EXPERIMENTATION

This committee was increased to five members and the President was instructed to make the appointments.

Report of the Committee on Resolutions

WHEREAS, It has been reported that the Bureau of Plant Industry of the United States Department of Agriculture contemplates the curtailment of variety studies in vegetables and the cessation of studies leading to the publication of variety monographs of the type represented by Bulletins 69 and 109 of that Bureau; and

WHEREAS, The great importance of such studies as a basis for clarifying and simplifying the nomenclature of vegetable varieties is clearly recognized by scientists, seedsmen, and commercial growers; and

WHEREAS, The nomenclature of vegetable varieties is at present in a serious state of confusion; and

WHEREAS, This confusion in variety names is detrimental to the best interests of the vegetable industry of America; therefore be it

RESOLVED, That, the American Society for Horticultural Science, in Annual Convention assembled, urges the Bureau of Plant Industry of the United States Department of Agriculture to extend its studies of vegetable varieties as rapidly as possible with a view to publishing authoritative monographs on the various species, and simplifying the nomenclature of vegetable varieties. Be it further

RESOLVED, That a copy of this resolution be forwarded by the Secretary of this Society to the Chief of the Bureau of Plant Industry.

WHEREAS, the American Society for Horticultural Science feels itself indebted to the Committee on Arrangements of St. Louis, representing Washington University, the Shaw Botanical Gardens and the Public Schools, for placing at its disposal excellent facilities for the holding of its annual meeting and for many other courtesies that have served to make its meeting both pleasant and profitable; therefore, be it resolved, that we express our appreciation of this kindness; and

WHEREAS, Experience shows that there are certain subjects presented at the meetings of this Society and certain sections of the Botanical Societies that are of equal interest to the members of both; therefore, be it resolved that we suggest the desirability of an attempt to so organize the programs in the future that papers covering these subjects be more completely available to all concerned; and

WHEREAS, experience shows that it is often impossible or impracticable for members of this Society located at points distant from places of meeting to attend the Association gatherings; therefore, be it resolved, that we look with favor upon the affiliation with this Society of sectional organizations of official horticulturists.

Respectfully submitted,

(Signed V. R. GARDNER,

J. K. SHAW,

B. S. PICKETT,

Committee on Resolutions.

Smoker

The smoker was, as usual, one of the most enjoyable features of the meeting. About 55 of our members and a few members of the American Pomological Society, spent the evening with Dr. L. H. Bailey as leader. Dr. Bailey chose as his subject the American Pomological Society. He spoke of the founders of the Society, of its early activities, of its present decline, and asked for suggestions looking toward its rejuvenation. After thorough discussion committees were appointed and plans adopted to bring this about. It was the opinion of most of those present that the revival of that old society is at hand.

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